NATIONAL BUREAU OF STANDARDS

NBS SPECIAL PUBLICATION 583

U.S. DEPARTMENT OF COMMERCE / National Bureau of Standards

Hydraulic Research in the United States and Canada, 1978

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Hydraulic Research in the United States and Canada, 1978

P. H. Gurewitz

Center for Mechanical Engineering and Process Technology
National Engineering Laboratory
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Issued October 1980

Library of Congress Catalog Card Number: 80-600124

National Bureau of Standards Special Publication 583
Nat. Bur. Stand. (U.S.), Spec. Publ. 583, 397 pages (Oct. 1980)
CODEN: XNBSAV

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON: 1980

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Price $8.50
(Add 25 percent for other than U.S. mailing)

ABSTRACT

Current and recently concluded research projects in hydraulics and hydrodynamics for the years 1977-1978 are summarized. Projects from more than 200 university, industrial, state and federal government laboratories in the United States and Canada are reported.

Key words: Fluid mechanics; hydraulic engineering; hydraulic research; hydraulics; hydrodynamics; model studies; research summaries.

ACKNOWLEDGEMENT

The editor gratefully acknowledges the valuable assistance of Dr. Gershon Kulin in the preparation of this document.

PREFACE

This publication first appeared in 1933 as "Hydraulic Research in the United States" in answer to a need to keep hydraulicians aware of pertinent current activity in research laboratories throughout the United States and Canada. With the exception of a few World War II years, it was published annually through 1966, after which publication became biennial. In 1972 the title was changed to "Hydraulic Research in the United States and Canada."

The National Bureau of Standards appreciates the cooperation of the more than 200 organizations which have contributed to this issue their summaries of hydraulic and hydrologic research and of other fluid mechanics research of interest and usefulness to hydraulicians. These reporting organizations are listed beginning on page vi. Although efforts are made to solicit reports from all laboratories whose work comes to our attention, the National Bureau of Standards cannot assume responsibility for the completeness of this publication. We must depend in the last analysis upon reporting laboratories for the completeness of the coverage of their own programs, and upon new laboratories engaged in pertinent research to bring their activities to our attention.

Detailed information regarding the research projects reported here should be obtained from the correspondent listed under (c) or immediately following the title and address of the organization reporting the work. The National Bureau of Standards does not maintain a file of publications, reports or other detailed information on research projects reported by other laboratories. It is of course understood that laboratories submitting reports on their work will be willing to supply additional information to properly qualified inquirers.

CONTENTS

KEY TO PROJECTS

The project summaries are grouped in three sections: (1) U. S. university, state and industrial laboratories, (2) U. S. Government laboratories, and (3) Canadian laboratories. Within each section the source laboratories are listed alphabetically (see List of Contributing Laboratories on page vi) and are numbered sequentially using the first three digits of the identification number.

(a) Project number and title
In the thirteen-digit identification number, e.g., 129-01111-000-00, preceding each title, the second (five-digit) group, e.g., 01111, is the project number. Once assigned, this number is repeated in each issue for identification purposes until the project is completed. In this issue the numbers 10800 and above are projects being reported for the first time.

(b) Project conducted for
Only out-of-house sponsors are listed here. Absence of an entry indicates in-house support.

(c) Correspondent
Where there is no entry here, refer to the correspondent cited directly following the title and address of the reporting laboratory.

(d) Nature of Project
Basic or applied; theoretical, experimental; thesis, etc.

(e) Description of Project

(f) Present Status
Absence of an entry here implies that the project was in an active status at time of submission.

(g) Results
In many continuing projects this section contains only results obtained since the previous issue of "Hydraulic Research in the United States and Canada." For completeness, readers are encouraged to consult earlier issues and/or publications listed under (h).

(h) Publications
For the continuing projects, only publications since the last issue are generally listed. Older publications are listed when there have been no new publications since the last issue or when a project is being reported for the first time. For completeness, readers are encouraged to consult earlier issues.

LIST OF CONTRIBUTING LABORATORIES

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U.S. GOVERNMENT AGENCIES

PROJECT REPORTS FROM UNIVERSITY, STATE, AND INDUSTRIAL LABORATORIES

UNIVERSITY OF AKRON, Department of Chemical Engineering, Akron, Ohio 44325. Dr. Howard L. Greene, Department Head.

001-07918-270-00

BIOMEDICAL IMPLICATIONS OF DRAG REDUCING AGENTS

(*c*) Drs. H. L. Greene, R. A. Mostardi, R. F. Nokes.
(*d*) Theoretical and experimental investigation involving basic and applied research. Some parts of the project have been undertaken as Masters and Doctoral theses.
(*e*) Research has been undertaken to investigate possible hydrodynamic and biological effects of soluble polymeric substances (drag reducing agents or DRA) on vascular blood flows. Possible relationships between vascular turbulence, atherogenesis, and fluid viscoelasticity have been examined both *in vivo* and *in vitro*.
(*g*) Major results to data indicate, firstly, that drag reduction occurs predictably in blood with DRA addition. Secondly, large reductions (~ 50 percent) in erythrocyte trauma during extracorporeal pumping occur with addition of DRA, probably because of viscoelastic lessening in the turbulent disturbances generated by such pumps. Thirdly, animal experiments using both rabbits and pigeons suggest that DRA may inhibit hydrodynamic damage in the vascular system, resulting in significant diminution of arterial disease.

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UNIVERSITY OF AKRON, Department of Civil Engineering, Akron, Ohio 44325. Dr. A. L. Simon, Department Head.

002-0415W-810-33

DEVELOPMENT OF LINEARIZED SUBHYDROGRAPH METHOD OF URBAN RUNOFF DETERMINATION .

(*b*) Office of Water Research and Technology.
(*c*) Dr. S. Sarikelle, Associate Professor.
(*e*) See *Water Resources Research Catalog* **11,** 4.0032.

002-0462W-810-33

DEVELOPMENT OF MATHEMATICAL MODEL FOR URBAN RUNOFF QUANTITY AND QUALITY

(*b*) Office of Water Research and Technology.
(*c*) Dr. S. Sarikell, Assoc. Professor.
(*e*) See *Water Resources Research Catalog* **11,** 4.0035.

002-09953-360-47

LABORATORY AND FIELD EVALUATION OF ENERGY DISSIPATORS AT CULVERT OUTLETS

(*b*) U.S. and Ohio Department of Transportation.
(*c*) Dr. S. Sarikelle, Associate Professor.
(*d*) Experimental, theoretical and applied research.
(*e*) Development of energy dissipator consisting of prefabricated modular units for culvert and storm drain outlets. Relationships between scour patterns and flow characteristics are investigated by laboratory tests. Prototype performance is determined by field studies.
(*g*) Prototype installation of several versions of the modular energy dissipator have been accomplished.
(*h*) **Field Performance of Concrete Pipe Internal Energy Dissipators,** S. Sarikelle, et al., presented *18th Ann. Transportation Research Board Mtg.*, Washington, D.C., Jan. 16, 1979.
Field and Laboratory Evaluation of Energy Dissipators, S. Sarikelle, A. L. Simon, Final Report, Hydraulics Lab., Univ. of Akron, Dec. 1978 (4 volumes).

002-10800-320-49

ROUGHNESS CHARACTERISTICS OF ROCK-LINED CHANNELS

(*b*) U.S. and Ohio Department of Transportation.
(*c*) Dr. A. L. Simon, Professor.
(*d*) Experimental and applied research.
(*e*) A field test program is established to measure roughness characteristics of rock-lined channels. Variation of the roughness factors is related to rock sizes and other variables by the use of theoretical and analytical procedures.

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UNIVERSITY OF AKRON, Department of Mechanical Engineering, Akron, Ohio 44325. Dr. R. J. Scavuzzo, Department Head.

003-09777-140-00

TURBULENT INTERNAL AND EXTERNAL FLOWS WITH HEAT TRANSFER

(*c*) Benjamin T. F. Chung.
(*d*) Theoretical basic research for Ph.D. and M.S. theses.
(*e*) Development of mathematical models for various complex transport processes.
(*h*) **The Surface Renewal Approach to Meddling Wall Turbulence,** L. C. Thomas, B. T. F. Chung, *Proc. Intl. Conf. Turbulent Flow with Heat or Mass Transfer Near the Wall Region Paris* (1977).
Unsteady Heat Transfer in Turbulent Flow Over a Flat Plate with Radiation Boundary Condition, B. T. F. Chung, L. T. Yeh, *Proc. 14th Ann. Seminar on Thermal Science*, 326 (1978).
Transient Heat Transfer for Turbulent Boundary Layer Flow with Effects of Wall Capacitance and Resistance, R. C. Wang, B. T. F. Chung, L. C. Thomas, *Heat Transfer in 1978*, **5,** 377 (1978).
A Surface Rejuvenation Model for Turbulent Heat Transfer in Annular Flow with High Prandtl Number, B. T. F. Chung, L. C. Thomas, Y. Pang, *J. of Heat Transfer, Trans ASME* **100,** 92 (1978).

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UNIVERSITY OF ALASKA, Geophysical Institute, Fairbanks, Alaska 99701. Dr. T. E. Osterkamp.

004-10801-390-00

FRAZIL ICE FORMATION

(*d*) Experimental, field, applied research.
(*e*) Identification and interpretation of the factors responsible for frazil ice growth in natural settings (lakes and rivers).

(*g*) Mass transfer processes have been shown to be responsible for frazil nucleation.
(*h*) **Frazil Ice Formation: A Review,** T. E. Osterkamp, *Proc. ASCE* **104,** HY9, Sept. 1978.

004-10802-340-00

ICE PROBLEMS ASSOCIATED WITH HYDROELECTRIC DEVELOPMENT IN COLD REGIONS

(*b*) CETA.
(*d*) Experimental, field, applied research.
(*e*) Identification and assessment of ice problems associated with hydroelectric power production in cold regions.
(*g*) Some potential ice problems have been identified and a preliminary assessment of them is in progress.
(*h*) **Some Potential Ice Problems Associated with Hydroelectric Development in Alaska,** T. E. Osterkamp, *The Northern Engineer* **9,** 2, p. 4-6, 1977.

004-10803-390-15

MEASUREMENT AND PREDICTION OF ICE FORCES ON HIGHWAY BRIDGES

(*b*) U.S Army, CRREL.
(*d*) Experimental, field, applied research.
(*e*) The goals of the project are to develop instrumentation and carry out measurements of ice forces on the Yukon River bridge.

004-10804-070-00

INVESTIGATION OF SALT TRANSPORT IN PERMAFROST SOILS

(*b*) CETA.
(*d*) Experimental, applied research.
(*e*) Salt transport studies in frozen soils under the influence of thermal, hydraulic and chemical potentials are in a preliminary stage.

ALDEN RESEARCH LABORATORY (of Worcester Polytechnic Institute) (See Worcester Polytechnic Institute Listing).

ARGONNE NATIONAL LABORATORY, Energy and Environmental Systems Division, 9700 So. Cass Ave., Argonne, Ill. 60439. Dr. John D. Ditmars, Manager, Water Resources Section.

005-09778-440-52

GREAT LAKES POLLUTANT TRANSPORT PROCESSES

(*b*) U.S. Energy Research and Development Administration.
(*c*) Dr. Kim D. Saunders.
(*d*) Theoretical and field investigation; basic and applied research.
(*e*) The spatial and temporal variation in nearshore (< 10 km offshore) currents and the near-bottom currents in central Lake Michigan are investigated. Data from this program and others are employed in evaluating the ability of numerical lake circulation models to predict the circulations and to estimate residence times for pollutants in both the nearshore zone of southwestern Lake Michigan and in the southern basin of the lake. The near-bottom currents are measured in support of sediment resuspension studies.
(*f*) Completed.
(*g*) Based on existing data, no numerical models tested have been able to predict the lake circulations with any degree of reliability. An empirical linear transfer function model has been able to account for about 80 percent of the variance caused by local winds. Pollution residence times are being computed at present.
(*h*) **Comparison of Model and Observed Currents in Lake Michigan,** J. H. Allender, *J. Physical Oceanography* **7,** 5, pp. 711-718 (1977).
Low Speed Calibration of the Bendix Q-15R Current Meter, K. D. Saunders, *J. Great Lakes Res.* **3,** 3-4, pp. 317-322 (1977).

005-09779-870-36

FATE OF REFINERY WASTES/INDIANA HARBOR CANAL

(*b*) U.S. Environmental Protection Agency, U.S. Energy Research and Development Administration, and Illinois Institute for Environmental Quality.
(*c*) Dr. Wyman Harrison.
(*d*) Field investigation; applied research.
(*e*) The transport and dispersion of oil-refinery wastes from the Indiana Harbor Canal into southwestern Lake Michigan are studied in the field using simulated waste and tracers. The wastes and subsurface waters are tagged with rare-earth tracers and dye, and the dispersing plumes are sampled for several days from a vessel. Summer conditions, when the canal outflow enters the lake at the surface, and winter conditions, when the canal outflow sinks below the lake surface, are both investigated.
(*f*) Completed.
(*g*) A simulated spill of oily waste and the underlying water in the Indiana Harbor Canal were tagged with two different rare-earth elements during wintertime sinking plume conditions. Neutron activation analysis of water samples collected at the City of Chicago's South water Filtration Plant indicated that tagged water had been transported to the raw water intakes at the plant. Water samples taken from Lake Michigan gave evidence of separate motion of the oily waste and underlying water.
(*h*) **Pollution of Coastal Waters Off Chicago by Sinking Plumes from the Indiana Harbor Canal,** W. Harrison, D. L. McCown, K. D. Saunders, L. A. Raphaelian, *Argonne Natl. Lab. Rept. ANL/WR-77-2* (1977).
Transport of Oily Pollutants in the Coastal Waters of Lake Michigan: An Application of Rare Earth Tracers, D. L. McCown, K. D. Saunders, L. H. Allender, J. D. Ditmars, W. Harrison, *Argonne Natl. Lab. Rept. ANL/WR-78-1* (1978).
Differential Tracking of Oily Wastes and the Associated Water Mass by Tagging with Rare Earths, D. L. McCown, *Water Res.* (in press).
Differential Tracking of Oily Wastes and the Associated Water Mass by Tagging with Rare Earths, D. L. McCown, *Proc. 3rd Symposium on Fugitive Emissions: Measurement and Control*, San Francisco (1978).
Wintertime Raw-Water Contamination at Chicago's South Water Filtration Plant, W. Harrison, D. L. McCown, K. D. Saunders, J. D. Ditmars, *J. Water Poll. Control Fed.* **51,** (in press) (1979).

005-09780-870-52

SUBMERGED DIFFUSER DISCHARGE ANALYSIS

(*b*) U.S. Energy Research and Development Administration.
(*c*) Dr. John D. Ditmars.
(*d*) Theoretical and field investigation; applied research.
(*e*) Submerged discharges of cooling waters from electric power generation into large bodies of water are investigated. Models for the prediction of the temperature fields of the resulting thermal plumes are evaluated. Prototype data are collected by Argonne at several sites on the Great Lakes using a towed thermistor cable, ranging system, and data acquisition system onboard a small boat. The three-dimensional temperature structure data gathered are employed for model evaluation. Ambient water temperature, circulation, and wind are monitored during plume mapping.
(*f*) Discontinued.
(*g*) Thermal plumes for relatively shallow-submergence discharges for the Zion Nuclear Power Station and the D. C. Cook Nuclear Power Plant on Lake Michigan have been mapped and studied. Field investigations have been initiated at the multiport diffuser of the J. A. FitzPatrick Nuclear Power Plant on Lake Ontario. Near-field dilutions

at the Zion site have been compared with model predictions, and the effects of current on single and adjacent pairs of discharges at that site have been documented.

(*h*) **Thermal Plumes from Submerged Discharges at Zion Nuclear Power Station: Additional Prototype Measurements of Interacting Plumes,** R. A. Paddock, A. A. Frigo, J. D. Ditmars, *Argonne Natl. Lab. Rept. ANL/WR-77-3* (1977).
Argonne National Laboratory's Thermal Plume Measurements: Instruments and Techniques, L. S. Van Loon, A. A. Frigo, R. A. Paddock, *Argonne Natl. Lab. Rept. ANL/WR-77-4* (1977).
Observations of Thermal Plumes from Submerged Discharges in the Great Lakes and Their Implications for Modeling and Monitoring, J. D. Ditmars, R. A. Paddock, A. A. Frigo, *Waste Heat Management and Utilization* **2**, pp. 1307-1328, S. S. Lee, S. Sengupta, eds., Hemisphere Publ. Corp., Washington, D.C. (1979).

005-11430-340-52

ONCE-THROUGH COOLING WATER TECHNOLOGY

(*b*) U.S. Department of Energy.
(*c*) Dr. Robert A. Paddock.
(*d*) Applied research.
(*e*) The results of mathematical models, physical models, and prototype measurements of thermal plumes have been used to assess the efficacy of once-through cooling systems in rivers, lakes, estuaries, and coastal waters. The performance of such systems was determined in terms of their ability to meet water quality standards for temperature and mixing zone geometry.
(*f*) Completed.
(*g*) The characteristics of once-through cooling systems, surface and submerged discharges, and of the receiving waters necessary to meet thermal standards for typical 500 and 1000 MWe nuclear- and fossil-fueled power plants were determined.
(*h*) **Assessment of Once-Through Cooling Water Control Technology,** R. A. Paddock, J. D. Ditmars, *U.S. DOE Environmental Control Symp.*, Washington, D.C., Nov. 1978 (in press).
An Assessment of the Once-Through-Cooling Alternative for Central Steam-Electric Generating Stations, R. A. Paddock, J. D. Ditmars, *Argonne Natl. Lab. Rept. ANL/WR-78-6* (1978).

005-11431-410-88

COASTAL TRANSPORT IN SOUTHWESTERN LAKE MICHIGAN

(*b*) Illinois Institute for Natural Resources.
(*c*) Dr. John D. Ditmars.
(*d*) Field investigation; applied research.
(*e*) The transport characteristics of the coastal currents in Lake Michigan between Milwaukee and Chicago were investigated in terms of data on currents obtained at 13 current meter stations along the 12-m isobath. Continuous current measurements were recorded for one year at current meters at mid-depth.
(*g*) Spatial and temporal characteristics of the currents have been determined from the data. The major components of the currents were found to be shore parallel in orientation. An optimal interpolation scheme was adopted to provide estimates of currents between measurement stations and used with s simple diagnostic tracer model to simulate southward transport of water parcels released at the northern stations.
(*h*) **Nearshore Currents in Lake Michigan Between Milwaukee and Chicago, 1977-1978: Implications for Transport,** K. D. Saunders, J. D. Ditmars, *Argonne Natl. Lab. Rept. ANL/WR-78-4*, (in press).

005-11432-410-55

NEARSHORE CIRCULATION MODEL VERIFICATION

(*b*) Nuclear Regulatory commission.
(*c*) Dr. John D. Ditmars.
(*d*) Field investigation, theoretical; applied research, numerical model for the vertically-averaged circulation driven by waves and wind in the extreme nearshore region.
(*e*) Field experiments at a beach on southwestern Lake Michigan were designed and performed for the evaluation of the predictive capabilities of a numerical model for the vertically-averaged circulation driven by waves and wind in the extreme nearshore region. Measurements of the wave field and onshore/offshore profiles of the longshore currents were made at 3-hour intervals for 27 hours during storms in the spring and autumn.
(*g*) Comparisons of model simulations with measurements indicated that predicted locations of the breaker zone are in rough accord with those observed during storms. Peak longshore currents near the breaker zone are simulated quite well, but the decays of wave height and of the strength of longshore currents across the surf zone are underestimated.
(*h*) **Comparison of Model and Observed Nearshore Circulation,** J. H. Allender, J. D. Ditmars, W. Harrison, R. A. Paddock, *Proc. 16th Intl. Conf. on Coastal Eng., ASCE,* Hamburg (1978).
Evaluation of a Numerical Model for Wave- and Wind-Induced Nearshore Circulation Using Field Data, J. H. Allender, J. D. Ditmars, A. A. Frigo, R. A. Paddock, *Argonne Natl. Lab. Rept. ANL/WR-78-3*, (in press).

ARIZONA STATE UNIVERSITY, Department of Chemical and Bio Engineering, Tempe, Ariz. 85281.

006-08825-250-54

DRAG REDUCING ADDITIVES

(*b*) NSF, ACS-PRF.
(*c*) Dr. Neil S. Berman.
(*d*) Experimental and theoretical basic and applied research.
(*e*) Experiments are continuing to measure the details of turbulent flow in dilute polymer solutions. A Two Component Laser Doppler Anemometer is used to determine turbulent intensities and correlations in small pipes. The results are sought for solutions in which the molecular properties have been altered by chemical means so the relationship between turbulent and molecular variables can be found.
(*g*) Previous results concerned the effect of molecular weight distribution, the solvent viscosity, and the molecular conformation. Current studies involve the sublayer period measured from short time autocorrelations near the wall. These measurements appear sensitive to probe size and the spanwise scale of large eddies.
(*h*) **Flow Time Scales and Drag Reduction,** N. S. Berman, *Phys. Fluids* **20,** S168 (1977).
Drag Reduction of the Highest Molecular Weight Fractions of Polyethylene Oxide, N. S. Berman, *Phys. Fluids* **20,** 715 (1977).
The Study of Drag Reduction Using Narrow Fractions of Polyox, N. S. Berman, J. Yuen, *Proc. 2nd Intl. Symp. on Drag Reduction*, C1-1, (Aug. 1977).
Drag Reduction by Polymers, N. S. Berman, *Ann. Review of Fluid Mechanics* **10,** 47-64 (1978).
An Observation of the Effect of Integral Scale on Drag Reduction, N. S. Berman, S. Griswold, S. Wlihu, J. Yuen, *AIChE J.* **24,** 124-130 (1978).

ARIZONA STATE UNIVERSITY, Department of Mechanical Engineering, Tempe, Ariz. 85281. Dr. Darryl Metzger, Department Chairman.

007-09931-140-50

MULTIPLE JET ARRAY IMPINGEMENT HEAT TRANSFER CHARACTERISTICS

(*b*) NASA Lewis.
(*c*) Professors L. W. Florschuetz and D. E. Metzger.

(*d*) Experimental, applied research, M.S. and Ph.D. theses.
(*e*) Study of flow dynamics and heat transfer on surfaces subjected to impingement from multiple jet arrays.
(*g*) Results cover cases where spent air from impinging jets exits the array in a single direction. The resulting crossflow/jet interaction leads to complex surface heat transfer behavior.
(*h*) **Heat Transfer Characteristics for Inline and Staggered Arrays of Circular Jets with Crossflow of Spent Air,** D. E. Metzger, L. W. Florschuetz, et al., *Gas Turbine Heat Transfer*, 1978, ASME, N.Y., pp. 9-19.

007-09932-050-70

JET IMPINGEMENT ON ROTATING SURFACES

(*b*) AiResearch Division of the Garrett Corporation.
(*c*) Professor D. E. Metzger.
(*d*) Experimental, applied research, M.S. theses.
(*e*) Study of flow dynamics and heat transfer on rotating surfaces cooled by single and multiple impinging jets.
(*f*) Completed.
(*g*) Results show a flow regime transition phenomena which significantly affects the heat transfer rate. Results also show a negligible effect of variations in disk face profiles representative of those encountered in turbine wheels.
(*h*) **Heat Transfer Between an Impinging Jet and a Rotating Disk,** D. E. Metzger, L. D. Grochowsky, *J. Heat Transfer* **99**, Nov. 1977.
Jet Cooling at the Rim of a Rotating Disk, D. E. Metzger, W. J. Mathis, *J. Engr. for Power* **101**, Jan. 1979.

007-09935-640-50

WAKES FROM BUILDINGS AND NATURAL OBSTACLES

(*b*) National Aeronautics and Space Administration.
(*c*) Professor Earl Logan.
(*d*) Experimental; applied; thesis.
(*e*) Investigation of the response of atmospheric turbulent boundary layers to obstacles of simple geometry.
(*g*) Incomplete.
(*h*) **A Comparison of Wake Characteristics of Model and Prototype Buildings in Transverse Winds,** E. Logan, P. Phataraphruk, J. Chang, *NASA-CR-3008*, May 1978.
Preliminary Comparison of Model and Prototype Wakes, E. Logan, D. W. Camp, *AIAA Paper 78-254*, Aerospace Sciences Meeting, Jan. 1978.
Building Wakes in Disturbed Layers, E. Logan, J. Chang, M. Alexander, *Conf. on Atmos. Environment of Aerospace Systems and Applied Meteorology*, Amer. Meteorol. Soc., pp. 87-92, Nov. 1978.

007-09936-210-00

TURBULENT FLOW OVER ROUGHNESS ELEMENTS

(*c*) Professor Earl Logan.
(*d*) Experimental; basic; thesis.
(*e*) Investigation of the response of turbulent pipe flow to ring-type roughness elements.
(*g*) Measurements of profiles of mean velocity, turbulence and Reynolds shear stresses accompanying the transformation from fully-developed smooth to fully-developed rough pipe and channel flow. Same measurements downstream of one or two roughness elements.
(*h*) **Response of a Turbulent Pipe Flow to a Change in Roughness,** W. D. Siuru, E. Logan, *J. Fluids Engrg.* **99**, Sept. 1977.
Response of a Turbulent Pipe Flow to a Single Roughness Element, P. Phataraphruk, E. Logan, *Developments in Theoretical and Applied Mechanics* **9**, 1978, pp. 139-149.

007-10805-140-70

HEAT TRANSFER IN DUCTS WITH PEDESTAL ARRAYS

(*b*) Pratt and Whitney Aircraft.
(*c*) Professor D. E. Metzger.
(*d*) Experimental, applied research, M.S. and Ph.D. theses.
(*e*) Study of flow dynamics and heat transfer in large aspect ratio ducts separated by rows of short pins or pedestals.
(*g*) Incomplete.

007-10806-140-70

ENTRANCE HEAT TRANSFER IN TUBES WITH A CROSS-FLOW SUPPLY

(*b*) Pratt and Whitney Aircraft.
(*c*) Professor D. E. Metzger.
(*d*) Experimental, applied research, M.S. theses.
(*e*) Study of flow dynamics and heat transfer in short branch tubes with a strong transverse flow component at the tube entrance.
(*f*) Completed.
(*g*) Resulting correlations of experimental work cover a wide range of tube length-to-diameter ratios, tube Reynolds numbers, and crossflow-to-throughflow velocity ratios. Significant heat transfer enhancement is attributed to the presence of the crossflow velocity component.
(*h*) **Entry Region Heat Transfer in Circular Tubes with a Crossflow Supply,** *MSE Thesis*, Mech. Engr., Arizona State Univ., May 1978.

UNIVERSITY OF ARIZONA, College of Agriculture, Department of Soils, Water and Engineering, Tucson, Ariz. 85721. Professor Delmar D. Fangmeier.

008-10807-840-05

BORDER AND FURROW IRRIGATION HYDRAULICS

(*b*) Arizona Agricultural Experiment Station and U.S. Water Conservation Laboratory.
(*d*) Experimental, applied research, Master's and Doctoral theses.
(*e*) Develop design criteria for sloping irrigation borders with no outflow at the downstream end and criteria for the design of reuse systems for irrigation runoff. A zero-inertia model of surface irrigation flow will be used to develop design data.
(*g*) Hydraulic characteristics of irrigation furrows have been studied. An analysis of Soil Conservation Service design curves using a computer model indicated the design criteria are reasonable.

008-10808-820-65

GROUNDWATER RESOURCES MANAGEMENT

(*b*) City of Tucson and Arizona Agricultural Experiment Station.
(*c*) Dr. Marshall Flug.
(*d*) Field investigation, applied research.
(*e*) Collection and analysis of land and water use data in Santa Cruz, Pima, and Yavapai Counties, Arizona. Annual data collected include static groundwater levels, estimates of water withdrawals, acreage of crops grown, water quality samples, and an analysis of well cuttings from new drilling activities. These data are used in evaluating the water supply and in estimating annual recharge.
(*g*) An event based model has been demonstrated which accurately predicts recharge to an ephemeral stream.

008-10809-840-00

TRICKLE IRRIGATION TO IMPROVE CROP PRODUCTION AND WATER MANAGEMENT

(*c*) A. W. Warrick.
(*d*) Primary emphasis is on cultural practice of citrus irrigation and subsurface distribution for line and point sources. The field studies include effects of water, fertilizers, and pests on plant establishment, growth and yield.
(*g*) For newly planted citrus, the amount of water is significantly less for citrus (on the border of 80-90 percent) than for flood irrigation without loss in growth. For mature trees the savings is less, perhaps 30 percent. Significant progress has been made for modeling soil water flow from point and line emitters. Graphs and slide-charts have been prepared to relate discharge amounts, spacings, root depth, water uptake amount and soil moisture.

(*h*) **Linear and Nonlinear Models of Infiltration from a Point Source,** J. Ben-Asher, D. O. Lomen, A. W. Warrick, *Soil Sci. Soc. Amer. J. 42:3-6*, 1978.

Flow from a Line Source above a Shallow Water Table, D. O. Lomen, A. W. Warrick, *Soil Sci. Soc. Amer. J. 41:849-852*, 1977.

Linearized Moisture Flow with Loss at the Soil Surface, D. O. Lomen, A. W. Warrick, *Soil Sci. Soc. Amer. J. 42:396-400*, 1978.

Time Dependent Solution to the One-Dimensional Linearized Moisture Flow Equation with Water Extraction, D. O. Lomen, A. W. Warrick. (Accepted, *J. of Hydrology*), 1978.

Ortho-Phosphoric Fertilizer in Trickle Irrigation, M. K. O'Neill, B. R. Gardner, R. L. Roth (submitted to A.A.A.S.), 1979.

Citrus Responses to Irrigation Methods, D. R. Rodney, R. L. Roth, B. R. Gardner, *Proc. Intl. Soc. Citriculture 1:106-110*, 1977.

Progress on Pressurized Irrigation in Citrus, R. L. Roth, B. R. Gardner, D. R. Rodney, *Yuma Citrus Field Day Bulletin*, Dec. 1, 1978.

Linearized Moisture Flow from Line Sources with Water Extraction, A. W. Warrick, A. Amoozegar-Fard, D. O. Lomen. (Accepted *ASAE Trans.*), 1978.

008-10810-820-00

SOIL WATER AND ITS MANAGEMENT IN THE FIELD

(*c*) A. W. Warrick, Professor.
(*d*) Experimental, theoretical.
(*e*) Overall the project deals with the interrelationships of water and solutes in soil. The spatial distribution of soil hydraulic properties is being determined for field size units (such as 15-20 hectares). Also of interest are the ramifications of the variability on prediction of mass fluxes of water and solutes.
(*g*) Most soil hydraulic parameters have a skewed distribution. Approximately 100 times as many samples are required to estimate mean values compared for hydraulic conductivity as for bulk density.
(*h*) **Predictions of Soil Water Flux Based Upon Field-Measured Soil Water Properties,** A. W. Warrick, G. J. Mullen, D. R. Nielsen, *Soil Sci. Soc. Amer. J. 41:14-19*, 1977.

Scaling Field-Measured Soil Hydraulic Properties by a Similar Media Concept, A. W. Warrick, G. J. Mullen, D. R. Nielsen, *Water Resources Res. 13:355-362*, 1977.

Areal Predictions of Soil Water Flux in the Unsaturated Zone, A. W. Warrick, *Proc. Irrig. Return Flow Conference*, pp. 225-231, May 16-17, Fort Collins, 1977.

Soil Water Regimes Near Porous Cup Water Samplers, A. W. Warrick, A. Amoozegar-Fard, *Water Resources Res. 13:023-207*, 1977.

Infiltration and Drainage Calculations Using Spatially Scaled Hydraulic Properties, A. W. Warrick, A. Amoozegar-Fard. Submitted to *Water Resources Research*, 1978.

Spatial Variability of *In Situ* **Available Water,** G. S. Gumaa, *Ph.D. Dissertation*, Univ. of Arizona, 1978.

BELL AEROSPACE TEXTRON, Propulsion Systems and Components, P.O. Box One, Buffalo, N.Y. 14240.

009-10811-130-60

DENSE PHASE PULVERIZED COAL FLOW

(*b*) New York State Energy Research and Development Authority.
(*c*) K. Berman, Project Manager.
(*d*) Analytical and experimental applied research.
(*e*) The dense phase pneumatic transport of pulverized coal is being investigated to obtain data and correlations for vertical straight lines, venturi orifices, vertical and horizontal bends, and flow branching. The effort will be conducted at elevated pressures. Solids-to-gas weight ratio (referred to ambient pressure) will be about 400.
(*g*) One-year effort, started February 1979.

BROWN UNIVERSITY, Division of Applied Mathematics, Providence, R.I. 02912.

011-10812-060-20

DYNAMICS OF STRATIFIED FLUIDS

(*b*) Fluid Dynamics Program, Office of Naval Research, and National Science Foundation.
(*c*) Professor C. H. Su.
(*d*) Analytical and numerical.
(*e*) Investigation of nonlinear effects of critical layer, three-dimensional stratified flows over a long obstacle.
(*h*) **Boundary-Value Problems in a Stratified Shear Flow with a Nonlinear Critical Layer,** S. B. Margolis, C. H. Su, *Phys. of Fluids* **21**, pp. 1247-1259 (1978).

Stratified Flows with Stagnation Points, W. Stevens, C. H. Su, to appear in *Phys. of Fluids*.

Three-Dimensional Stratified Flows Over An Obstacle, *Ph.D. Thesis*, W. K. Stevens.

011-10813-420-54

INTERACTION OF SOLITARY WAVES

(*b*) Fluid Mechanics Program, Office of Naval Research, and National Science Foundation.
(*c*) Professor C. H. Su.
(*d*) Analytical and numerical.
(*e*) Investigation of nonlinear interaction (head-on collision) of two solitary waves, phase change and emission of secondary waves.
(*h*) **Head-On Collision Between Two Solitary Waves,** *Ph.D. Thesis*, R. M. Miric.

011-10814-190-52

INTERFACIAL PROBLEMS

(*b*) Department of Energy.
(*c*) Professor D. Y. Hsieh.
(*d*) Theoretical.
(*e*) Various aspects of interfacial flow probelms including bubble dynamics and interfacial stability problems.
(*h*) **Interfacial Stability with Mass and Heat Transfer,** *Phys. Fluids* **21**, pp. 745-748 (1978).

Variational Methods and Matheiu Equations, *J. Math. Phys.* **19**, pp. 1147-1151 (1978).

Forced Oscillations of Nonspherical Bubbles, *Report No. COO-4155-4*, Div. Appl. Math., Brown Univ. (1974).

Nonlinear Rayleigh-Taylor Stability With Mass and Heat Transfer, *Div. Appl. Math. Rept.*, Brown Univ. (1978).

BROWN UNIVERSITY, Division of Engineering, Providence, R.I. 02912. R. J. Clifton, Professor and Chairman, Executive Committee.

012-10815-130-54

NUCLEATION RATE MEASUREMENTS

(*b*) National Science Foundation.
(*c*) Professor Richard A. Dobbins.
(*d*) Experimental, theoretical investigation; basic research.
(*e*) The measurement of nucleation rate of water vapor by the observation of the transitional temperature history through the nucleation process; the understanding of the mechanisms which dominate the dynamics of the nucleation pulse.
(*g*) The temperature history during nucleation yields a direct determination of nucleation rate for water vapor; the nucleation growth integral is evaluated to afford a separa-

tion of the separate influences of the nucleation rate and the growth rate.

(*h*) **Application of the Method of Laplace to the Measurement of Homogeneous Nucleation Rates,** R. A. Dobbins, T. I. Eklund, *J. Aerosol Science* **5,** 1974, pp. 497-505.
Application of the Hot Wire Anemometer to Temperature Measurement in Transient Gas Flows, R. A. Dobbins, T. I. Eklund, *Intl. J. Heat and Mass Transfer* **20,** pp. 1051-1058 (1977).
The Direct Measurement of the Nucleation Rate Constants, R. A. Dobbins, T. I. Eklund, presented *ASME Symp. Condensing Flows*, New Haven, 15-17 June 1977.

012-10816-020-54

STUDIES OF SHEAR FLOW INSTABILITIES AND INTERNAL WAVE DEVELOPMENT

(*b*) National Science Foundation and Office of Naval Research.
(*c*) Professor J. T. C. Liu.
(*d*) Theoretical; basic research.
(*e*) Studies of coherent structures in laminar and turbulent shear flows; sound generated by coherent structures in turbulent jets. Breakdown of internal waves, generation of gravity waves by submerged regions of turbulence.
(*g*) Reported in (h).
(*h*) **Energy Integral Description of the Development of Kelvin-Helmholtz Billows,** J. T. C. Liu, L. Merkine, *Tellus* **28,** 197, 1976.
On the Interactions Between Large-Scale Structure and Fine-Grained Turbulence in a Free Shear Flow: Part I. The Development of Temporal Interactions in the Mean, J. T. C. Liu, L. Merkine, *Proc. R. Soc. Lond. A* **352,** 213, 1976. **Part II. The Development of Spatial Interactions in the Mean,** J. T. C. Liu, A. Alper, *Proc. R. Soc. Lond. A* **359,** 497, 1978. **Part III. A Numerical Solution,** T. B. Gatski, J. T. C. Liu, *Phil. Trans. R. Soc. Lond. A* (to appear), 1979.
The Large-Scale Organized Structure in Free Turbulent Shear Flow and its Radiation Properties, J. T. C. Liu, A. Alper, R. Mankbadi, in *Structure and Mechanisms of Turbulence II*, ed. H. Fiedler. Springer-Verlag, Berlin 1978.
Generation of Interfacial Gravity Waves by Submerged Regions of Fluctuating Hydrodynamical Motions and Fluid Inhomogeneities, J. T. C. Liu, *Physics of Fluids* (to appear), 1979.

CALIFORNIA INSTITUTE OF TECHNOLOGY, Division of Engineering and Applied Science, Environmental Quality Laboratory, Pasadena, Calif. 91125. Dr. Roy W. Gould, Division Chairman.

013-11700-830-80

SEDIMENT MANAGEMENT FOR SOUTHERN CALIFORNIA MOUNTAINS, COASTAL PLAINS AND SHORELINE

(*b*) Ford Foundation, U.S. Geological Survey, Los Angeles County, Orange County, Corps of Engineers, State of California, U.S. Forest Service, Southern Pacific Railroad.
(*c*) Norman H. Brooks, Director, Environmental Quality Laboratory, and James Irvine, Professor of Environmental and Civil Engineering.
(*d*) Field studies; applied research.
(*e*) Quantitative identification of sedimentation processes for 450 km reach of shoreline and its associated inland drainage in Southern California; with identification of the effects of man-made structures (reservoirs, flood control systems, harbors, breakwaters, etc.) on individual sedimentation processes and the overall natural system.
(*g*) Southern California geology and climate combine to produce active surface processes inland and along the coast. Natural erosion processes acting on 30,000 km^2 of coastal drainage between Pt. Conception and the USA/Mexico Border deliver some 12 million m^3 of debris each year (average) to urbanized plains areas and the shoreline. About half of this material is silt and clay, and the remainder is sand. Existing artificial control structures have severely interfered with natural sediment movements, reducing the average coastal sediment delivery of sand from 11 major rivers by one third or 500,000 tonnes per year. As a result, coastal beaches have been deprived of natural replenishments.
(*h*) **Sediment Management for Southern California Mountains, Coastal Plains, and Shoreline–Final Report for Phase I,** Norman H. Brooks, et al., *Environmental Quality Laboratory Report No. 16* (in preparation).

CALIFORNIA INSTITUTE OF TECHNOLOGY, Graduate Aeronautical Laboratories, Pasadena, Calif. 91125. Dr. Hans W. Liepmann, Laboratory Director.

014-10817-020-20

STRUCTURE OF TURBULENT FLOW

(*b*) Department of the Navy (Office of Naval Research).
(*c*) Professor Garry L. Brown.
(*e*) This is part of a continuing effort to understand the structure of turbulent shear flows, with present attention focused mainly on mixing layers and wakes. In the plane mixing layer, it has been found that at a certain Reynolds number, at which the flow is already turbulent, a new structure appears, superimposed on the main, quasi two-dimensional vortices or rollers which play the primary role in the development of the mixing layer. The new structures appear on shadowgraphs (viewed normal to the shear layer) as streamwise streaks, and are believed to be streamwise vortices of the Taylor type which have developed as secondary instabilities. We are attempting to describe a model of their topology consistent with the observations, but this is still speculative and we are developing other measurements to clarify the picture. The appearance of these secondary structures is believed to be important in the development of three-dimensionality in the flow. It is interesting that this does not destroy the basic structure of the larger, quasi two-dimensional, controlling structures, but is probably an important contribution to the three-dimensional dissipative mechanisms needed at high Reynolds number.
(*h*) **An Experimental Investigation of Mixing in Two-Dimensional Turbulent Shear Flows with Applications to Diffusion-Limited Chemical Reactions,** J. H. Konrad, *Ph.D. Thesis*, California Inst. of Tech., 1977 (also *Project SQUID Technical Report CIT-8-PU*, Purdue University, Dec. 1976).

014-10818-020-26

MIXING IN A REACTING TURBULENT SHEAR LAYER

(*b*) Department of the Air Force (Air Force Office of Scientific Research).
(*c*) Professor Anatol Roshko.
(*e*) As part of a continuing investigation of turbulent shear flows, a new water tunnel has been constructed to study the mixing in chemically reacting, turbulent shear layers. The test section is 7 cm by 11 cm in cross section with flow speeds up to 6 meters per second. The blow down tunnel is designed to handle a variety of dilute aqueous solutions. The reactants in the two streams can be chosen so that upon intimate molecular mixing, they react to form a visible reaction product. The production and accumulation of this product can be readily observed. The product tends to be distributed in clumps, associated with large scale vortical structures in the turbulent mixing layer. In these aqueous solutions the Schmidt number (the ratio of diffusion coefficients of momentum and mass) is about three orders of magnitude larger than in most gases, where it is near unity. Thus the Schmidt number effect on the mixing may be observed by comparing measurements in water with previous results obtained in gas flows.

014-10819-020-54

STRUCTURE AND ENTRAINMENT IN THE PLANE OF SYMMETRY OF A TURBULENT SPOT

(*b*) National Science Foundation.
(*c*) Professor Donald E. Coles.
(*e*) Laser-Doppler velocity measurements in water are reported for the flow in the plane of symmetry of a turbulent spot. The nonsteady mean flow, defined as an ensemble average, is fitted to a conical growth law by using data at three streamwise stations to determine the virtual origin in x and t. The two-dimensional nonsteady stream function is expressed as psi= $U^2 tg(\xi,\eta)$ in conical similarity coordinates $\xi = x/U_\infty t$, $\eta = y/U_\infty t$. In these coordinates, the equations for nonsteady particle displacements reduce to an autonomous system. This system is integrated graphically to obtain particle trajectories in invariant form. Strong entrainment is found to occur along the outer part of the rear interface and also in front of the spot near the wall. The outer part of the forward interface is passive. In terms of particle trajectories in conical coordinates, the main vortex in the spot appears as a stable focus with a celerity of 0.77 U_∞. A second stable focus with a celerity of 0.64 U_∞ also appears near the wall at the rear of the spot. Some results obtained by flow visualization with a dense, nearly opaque suspension of aluminum flakes are also reported. Photographs of the sublayer flow as viewed through a glass wall show the expected longitudinal streaks. These are tentatively interpreted as longitudinal vortices caused by an instability of Taylor-Görtler type in the sublayer.
(*h*) **Structure and Entrainment in the Plane of Symmetry of a Turbulent Spot**, B. Cantwell, D. Coles, P. Dimotakis, *J. Fluid Mechanics* 87, 4, pp. 641-672 (1978).

014-10820-020-20

FLOW VISUALIZATION AND LASER DOPPLER VELOCIMETRY MEASUREMENTS IN THE MIXING LAYER

(*b*) Department of the Navy (Office of Naval Research).
(*c*) Professor Paul E. Dimotakis.
(*e*) Investigations on the large structure interactions were conducted in a mixing layer in the Caltech Free Surface Water Tunnel. Multiple dye injector flow visualization and two-point laser Doppler velocity measurements indicate that even though the interactions are predominantly two-dimensional, departures do occur and helical coalescence of adjacent structures is occasionally observed.

014-10821-710-26

LASER INDUCED FLUORESCENCE IN TURBULENT MIXING FLOWS

(*b*) Department of the Air Force (Air Force Office of Scientific Research).
(*c*) Professor Paul E. Dimotakis.
(*e*) Laser induced fluorescence has been successfully employed to uniquely label one of two fluids undergoing turbulent mixing. As of this writing, high spatial resolution and excitation and photographic recording have been used to investigate the turbulence associated with an axisymmetric jet. Electrooptic imaging techniques, currently under development, will permit efficient recording and subsequent computer analysis of the turbulent flow field.

014-10822-530-21

CAVITATING HYDROFOIL FLUTTER

(*b*) Department of the Navy (Naval Ship Research and Development Center).
(*c*) Professor Christopher Brennen.
(*d*) Primarily experimental; Ph.D. thesis.
(*e*) Many incidental observations in the past have indicated that the presence of cavitation has a large effect on the hydroelastic behavior of pumps, hydrofoils, propellors and surface piercing struts. The present investigation, which is primarily experimental, is directed toward identification of these effects and of the leading edge flutter of supercavitating foils in particular. Experiments have been carried out in the Free-Surface and High Speed Water Tunnels of the Hydrodynamics Laboratory in which leading-edge flutter has been observed and investigated. It appears that the periodic shedding and collapse of cavitating clouds in the region of the cavity play a major role in the hydro-elastic behavior of supercavitating hydrofoils.
(*h*) **On the Leading-Edge Flutter of Supercavitating Hydrofoils**, K. Oey, *ASME Cavitation and Polyphase Flow Forum*, June 1978.

014-10823-010-20

THE EFFECTS OF CONTROLLED DISTURBANCES ON BOUNDARY LAYER TRANSITION IN WATER

(*b*) Department of the Navy (Office of Naval Research).
(*c*) Professor Hans W. Liepmann.
(*d*) Primarily experimental.
(*e*) The purpose, in general, is to study the effect of destabilizing and stabilizing disturbances on laminary instability, transition, and turbulent boundary layers, and in particular, to investigate buoyancy effects as a possible limiting factor in stabilizing water boundary layers by heat transfer from the wall; to develop a system of surface heat elements with the aim to both induce and control the amplification of laminar instability waves; and to study the effect of such elements on turbulent boundary layers, with the aim to control the coherent structures. This work is being carried out in the Caltech High-Speed Water Tunnel.

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CALIFORNIA INSTITUTE OF TECHNOLOGY, Division of Engineering and Applied Science, W. M. Keck Laboratory of Hydraulics and Water Resources, Pasadena, Calif. 91125. Dr. Roy W. Gould, Division Chairman.

015-11614-420-54

A STUDY OF TSUNAMIS: THEIR GENERATION, PROPAGATION, AND COASTAL EFFECTS

(*b*) National Science Foundation.
(*c*) Professor Fredric Raichlen.
(*d*) Experimental and theoretical; basic research.
(*e*) Two aspects are currently under investigation: the reflection, transmission, and propagation over a change in depth of long waves, and the effect of linear and nonlinear transient waves on harbors. In the former study solitary waves and finite amplitude periodic long waves have been used with the emphasis placed on the process of reflection by features similar to the continental shelf-break and slopes which vary from gentle to abrupt. The transmission and propagation of these waves on the shelf and runup on slopes is also an important aspect of the research. The second program is an investigation of the linear and nonlinear transient excitation of harbors. Experiments are performed in conjunction with analysis to determine the relative importance of dissipation and nonlinear effects in the process of transient harbor resonance.
(*h*) **Tsunamis–The Propagation of Long Waves Onto a Shelf,** D. G. Goring, *W. M. Keck Lab. of Hydraulics and Water Resources, Rept. No. KH-R-38*, Calif. Inst. of Tech., Pasadena, Calif., 377 pp., Nov. 1978.

015-11615-870-50

INVESTIGATIONS OF PROBLEMS OF LNG SPILL HAZARD ASSESSMENT

(*b*) National Aeronautics and Space Administration; California Institute of Technology's President's Fund.
(*c*) Professor E. J. List.
(*d*) Literature review.
(*e*) Review of the fluid dynamics and heat transfer problems associated with possible spills of liquefied natural gas LNG.

015-11616-050-54

SURFACE SPREADING OF BUOYANT JETS

(*b*) National Science Foundation.
(*c*) Professor E. John List.
(*d*) Theoretical and experimental; basic research Doctoral theses.
(*e*) The spreading of a miscible buoyant fluid on the surface of another is being studied, particularly, when entrainment ceases and the mixing layer collapses.
(*h*) **Spreading of Buoyant Discharges,** J.-C. Chen, E. J. List, *Proc. Intl. Sem. Turbulent Buoyant Convection*, Dubrovnik, Yugoslavia, Aug.-Sept. 1976.

015-11617-060-54

INTERFACIAL FRICTION AND MIXING IN A DENSITY-STRATIFIED TURBULENT FLOW

(*b*) National Science Foundation.
(*c*) Dr. Gregory Gartrell, Jr., Professor Norman H. Brooks and Professor E. John List.
(*d*) Experimental and theoretical; basic research; Ph.D. theses.
(*e*) The mixing processes which occur in a density-stratified turbulent shear flow were studied experimentally in the 40 m flume in the Keck Hydraulics Laboratory. The flume has been modified to allow a co-current flow of a warm shallow layer of water over a colder layer. The upper and lower layers of water are recirculated using independent pumping systems, while steam heating and the addition of cold water are used to ensure constant inlet conditions. A two-component laser-Doppler velocimeter allows the simultaneous measurment of two orthogonal fluid velocity components. These velocity measurements, along with detailed temperature measurements, yielded information on the fundamental mechanisms of the mixing at the interface of a density-stratified shear layer.
(*f*) Completed.
(*g*) Small density differences between the two layers can have a large effect on the flow. In some cases, the initial turbulent mixing layer will collapse to a laminar interface. If the boundary-generated turbulence level is sufficiently large downstream, the interface may become unstable and some mixing will occcur. The stratification greatly reduces the turbulence level, however, and consequently mixing is inhibited. In one case in which teh relative density difference was 2.3×10^4, far downstream the r.m.s. values of the velocity fluctuations were reduced to less than 25 percent of the values found in an identical case *with no* density difference; furthermore, the Reynolds stress, $-\overline{\rho u'v'}$ was reduced by 50 percent in the region of the density interface.
(*h*) **Studies on the Mixing in a Density-Stratified Shear Flow,** G. Gartrell, *W. M. Keck Lab. of Hydraulics and Water Resources, Rept. No. KH-R-39*, California Inst. of Tech., Pasadena, Calif. 91125, 498 pp., May 1979.

015-11618-700-54

DEVELOPMENT OF AN OCEANOGRAPHIC LASER-DOPPLER ANEMOMETER

(*b*) National Science Foundation.
(*c*) Professor E. J. List.
(*d*) Experimental research.
(*e*) Modification of triple-beam laser-Doppler anemometer for oceanographic velocity measurement.
(*h*) **A Signal Processor for a Laser-Doppler Velocimeter,** G. Gartrell, *W. M. Keck Lab. of Hydraulics and Water Resources, Tech. Memo No. 7805*, California Inst. of Tech., Pasadena, Calif. 91125, Apr. 1978.

015-11619-050-54

TURBULENT JET ENTRAINMENT

(*b*) National Science Foundation.
(*c*) Professor E. J. List.
(*d*) Experimental and theoretical; basic research; Ph.D. theses.
(*e*) The turbulent entrainment into vertical jets and plumes is being studied with a view to resolving the debate concerning entrainment coefficients for buoyant jets. Dimensional analysis is being used to predict the basic form of the entrainment function. Experimental studies of two-dimensional buoyant jets in which velocities and density anomalies are measured are used to relate the jet properties to the local jet Froude number.
(*f*) Completed.
(*g*) The entrainment coefficient has been found to be a function of the local jet Froude number and a jet expansion coefficient. Explicit forms have been found for the momentum flux and volume flux in turbulent buoyant jets by expanding the functional form for entrainment in terms of the inverse jet Froude number and the slowly varying expansion coefficient. Good agreement with previously published experimental results for axisymmetric buoyant jets has been found. The experimental studies of two-dimensional buoyant jets show that local turbulence properties in the jets are strongly dependent on the local Froude number. Explicit relations have been found for the growth of two-dimensional jets with buoyancy.
(*h*) **Turbulent Measurements in a Two-Dimensional Buoyant Jet Using Laser-Doppler Velocimetry,** N. E. Kotsovinos, E. J. List, *Proc., Laser-Doppler Anemometry Symp. 1975*, Technical University of Denmark, Aug. 25-29, 1975.
A Study of the Entrainment and Turbulence in a Plane Buoyant Jet, N. E. Kotsovinos, *W. M. Keck Lab. of Hydraulics and Water Resources, Rept. No. KH-R-32*, California Inst. of Tech., Pasadena, Calif. 91125, 306 pp., Aug. 1975.
Turbulent Buoyant Jets, N. E. Kotsovinos, E. J. List, *Proc., Intl. Sem. Turbulent Buoyant Convection*, Dubrovnik, Yugoslavia, pp. 349-369, Aug. 30-Sept. 4, 1976.
A Note on the Spreading Rate and Virtual Origin of a Plane Turbulent Jet, N. E. Kotsovinos, *J. Fluid Mechanics* **77,** Part 2, pp. 305-311, 1976.
Plane Turbulent Buoyant Jets. Part 1. Integral Properties, N. E. Kotsovinos, E. J. List, *J. Fluid Mechanics* **91,** Part 1, pp. 25-44, June 9, 1977.
Plane Turbulent Buoyant Jets. Part 2. Turbulence Structure, N. E. Kotsovinos, *J. Fluid Mechanics* **81,** Part 1, pp. 45-62, June 1977.
A Study of the Interactions of Turbulence and Buoyancy in a Plane Vertical Buoyant Jet, N. E. Kotsovinos, *Proc. Intl. Sem. Turbulent Buoyant Convection*, Dubrovnik, Yugoslavia, pp. 15-26, Aug. 30-Sept. 4, 1976.

015-11620-050-54

BUOYANT JETS IN CROSSFLOWS

(*b*) National Science Foundation.
(*c*) Professor E. J. List, Professor Norman H. Brooks.
(*d*) Experimental and theoretical research; Ph.D. theses.
(*e*) The interactions between vertical buoyant jets and ambient crossflows with and without density stratifications were studied. Experiments were performed without ambient turbulence by towing a negatively buoyant downward pointing jet along the surface of a laboratory tank containing the ambient fluid. Dimensional analysis coupled with simple force balance ideas was used to predict jet trajectories and dilutions for four different limiting cases (near-field vs far-field, buoyancy-dominated vs momentum-dominated).
(*f*) Completed.
(*g*) The theoretical model consists of four different flow regimes involving different trajectory and dilution relations. The model predicts trajectories and dilutions for a particular flow regime to within a constant that must be experimentally determined. The values of the various constants have been obtained in the experimental study. The model provides a unifying framework within which to place previous turbulent jet studies in crossflows. When the ambient fluid is density-stratified the problem can still be solved using the same type of approach but it is necessary to introduce two new length scales based on the Brunt-Vaisala frequency and the specific momentum and buoyancy fluxes of the jet.

(*h*) **Mean Behavior of Buoyant Jets in a Crossflow,** S. J. Wright, *J. Hydraulic Division, ASCE* **103**, HY5, pp. 499-513, 1977.
Effects of Ambient Crossflows and Density Stratification on the Characteristic Behavior of Round, Turbulent Buoyant Jets, S. J. Wright, *W. M. Keck Lab. of Hydraulics and Water Resources Rept. No. KH-R-36*, California Inst. of Tech., Pasadena, Calif. 91125, 254 pp., May 1977.
Effects of Ambient Current and Density Stratification on Buoyant Jets, S. J. Wright, *Proc. 25th Ann. Hydraulics Div. Speciality Conf.*, Texas A&M Univ., College Station, Tex., pp. 336-343, Aug. 10-12, 1977.

015-11621-870-75

MODEL STUDIES OF WASTE WATER PLUMES FOR SAN FRANCISCO SOUTHWEST OCEAN OUTFALL PROJECT

(*b*) CH_2M Hill, Inc., San Francisco (for City and County of San Francisco).
(*c*) Professor Norman H. Brooks or Dr. Robert C. Y. Koh.
(*d*) Experimental; design.
(*e*) Three outfalls are being designed: one for dry-weather sewage effluent with peak flow of 295 cfs (8.35 m^3/s) terminating in 75-foot (23 m) depth with a 3050-foot (930 m) multiport diffuser; the other two carry wet-weather combined sewage and street runoff at flows up to 372 cfs (10.6 m^3/s) to depth of 50 feet (15 m), each discharging through a 1440 ft (440 m) multiport diffuser. The required nominal dilutions are 100:1 for the dry weather and 25:1 for the wet weather outfalls. Since the pipes are buried, the ports are grouped on riser pipes. Sectional hydraulic model studies in a 2-ft wide 35-ft long glass-walled flume were conducted for different diffuser configurations for various conditions of current and density stratification in the ocean. Performance was evaluated by measuring dilutions and plume height of rise.
(*f*) To be completed with final confirming tests, summer 1979.
(*g*) Up to four ports per riser gave dilutions as good as for single ports spaced closer to give the same discharge per unit diffuser length. Laboratory results also validated Koh's mathematical model which was used as a design tool in conjunction with lab tests.
(*h*) **Sectional Hydraulic Modeling Study of Plume Behavior: San Francisco Southwest Ocean Outfall Project, Progress Report,** M. S. Isaacson, R. C. Y. Koh, N. H. Brooks, *W. M. Keck Lab. of Hydraulics and Water Resources, Tech. Memo 78-2*, California Inst. of Tech., Pasadena, Calif. 91125, 97 pp., Jan. 1978; and *Progress Report No. 2, Tech. Memo 78-4*, 31 pp., May 1978, (Final Report to be issued Fall 1979).

015-11622-220-54

UNSTEADY SEDIMENT TRANSPORT MECHANICS IN ALLUVIAL STREAMS

(*b*) National Science Foundation.
(*c*) Professor N. H. Brooks or Dr. R. C. Y. Koh.
(*d*) Theoretical and experimental basic research; Ph.D. theses.
(*e*) Develop a mathematical model for application to certain simple cases of unsteady nonuniform sediment laden flows. The model will then be tested against laboratory flume data. The required closure relations between sediment concentration and friction factor on the one hand and other basic flow and sediment variables such as velocity, depth, sediment size, etc., will be extracted from a sediment data bank consisting of several thousand data points.

015-11623-050-36

LARGE SCALE MIXING AND GRAVITATIONAL SPREADING FOR FINITE LINE PLUMES IN A CROSS-FLOW

(*b*) Environmental Protection Agency; National Science Foundation.
(*c*) Professor Norman H. Brooks.
(*d*) Experimental; basic research; Ph.D. theses.
(*e*) The three-dimensional flow field created by a simple line plume of finite length in a steady current of uniform density was investigated in a laboratory basin. The results can be used to aid in the prediction of dispersion of buoyant waste water released from line diffusers, particularly sewage discharges into the ocean.
(*f*) Completed.
(*g*) The flow pattern and the dimensionless dilution parameter are governed by the orientation angle Θ of the line source with respect to the current Froude number $F = u_a^3/b$, where u_a = ambient current and b = source buoyancy flux (per unit length). For small F, the lateral spreading is strong, and dilutions are close to those calculated for simple line plumes. For large F, the plume is advected downstream rapidly with slow spreading, and dilution depends on Θ (largest for line source perpendicular to current).
(*h*) **Dispersion of Buoyant Waste Water Discharged from Outfall Diffusers of Finite Length,** P. J. W. Roberts, *W. M. Keck Lab. of Hydraulics and Water Resources, Rept. No. KH-R-35*, California Inst. of Tech., Pasadena, Calif., 183 pp., Mar. 1977.
Line Plume and Ocean Outfall Dispersion, P. J. W. Roberts, *J. Hydraulics Div., ASCE* **105**, HY4, pp. 313-331, Apr. 1979.

015-11624-870-73

THERMAL DIFFUSION DURING HEAT TREATMENT CYCLES

(*b*) Southern California Edison Company.
(*c*) Dr. Morton S. Isaacson, Dr. R. C. Y Koh and Dr. E. J. List.
(*d*) Applied.
(*e*) Various hydraulic model tests were performed in order to determine the behavior of the ocean thermal discharge plumes resulting from the heat treatment of Units 2 and 3 of the San Onofre Nuclear Generating Station near San Clemente, California. Intake and discharge structures for all three units at San Onofre were included in the model.
(*f*) Completed.
(*g*) The results of the study augmented by previous studies, show that for both intake and diffuser heat treatment, the maximum dimension of the heat treatment plume, as defined by the 4 °F above ambient isotherm, is less than 2000 ft. within two hours following the end of heat treatment; the plume does not impact the shoreline or the bottom; and the water ingested by normally operating intakes is raised by less than 0.5 °F above ambient.
(*h*) **Hydraulic Investigations of Thermal Diffusion During Heat Treatment Cycles, San Onofre Nuclear Generating Station Units 2 and 3,** M. Isaacson, R. C. Y. Koh, E. J. List, *W. M. Keck Lab. of Hydraulics and Water Resources, Tech. Memo 76-2*, 268 pp., Dec. 1976.
Hydraulic Investigations of Thermal Diffusion during Heat Treatment Cycles, San Onofre Nuclear Generating Station Units 2 and 3, *Proc. Waste Heat Management and Utilization Conf.*, Miami Beach, Fla., May 9-11, 1977.

015-11625-870-65

DISPERSION OF PARTICULATES IN OCEAN SLUDGE DISPOSAL

(*b*) City of Los Angeles, County Sanitation Districts of Los Angeles County and Orange County.
(*c*) Professors Norman H. Brooks, J. J. Morgan, Dr. R. C. Y. Koh.
(*d*) Applied research.
(*e*) This is part of an assessment of alternatives for ocean sludge disposal. A simulation model is developed for estimating the dispersion and fallout of particulates as a result of discharging sewage sludge in the ocean. The deposition pattern depends on bathymetry, ocean current characteristics and particle fall velocities. Results from the model are integrated with chemical and biological aspects towards an overall assessment of ocean sludge disposal alternatives for Southern California.
(*f*) Completed.

(*h*) **Assessments of Alternative Ocean Sludge Disposal Practices,** G. A. Jackson, R. C. Y. Koh, N. H. Brooks, J. J. Morgan, *Final Report to City of Los Angeles*, County Sanitation Districts of Los Angeles County, County Sanitation Districts of Orange County through Los Angeles/Orange County Metropolitan Area Regional Wastewater Solids Management Program, *Environmental Quality Lab. Rept. No. 14*, California Inst. of Tech., Pasadena, Calif. 91125, Oct. 1978.

015-11626-220-54

MECHANISMS OF THE ENTRAINMENT AND SUSPENSION OF SEDIMENT DURING TRANSPORT BY WATER

(*b*) National Science Foundation.
(*c*) Professor Norman H. Brooks.
(*d*) Experimental; basic research; Ph.D. theses.
(*e*) A laser-Doppler system has been developed to measure not only fluid velocity but also the suspended sediment velocity and concentration throughout the water column. Previous applications of laser velocimetry have been primarily in flows transporting dilute concentrations of small (2-20 μ) fluid tracer particles. In this study, relatively large (100-1000 μ) sand grains at high concentrations are also being transported by the fluid. To observe both types of particles and to measure both the fluid and suspended sediment velocities, with minimum degradation of signal quality, nonstandard optics (using a larger beam intersection angle) have been developed.
Suitable data acquisition and processing electronics have been developed. These include a pulse height detector which identifies each scattering particle as sand grain or fluid tracer and a zero-crossing counter which measures the velocity of each scattering particle. Signals are processed by the laboratory minicomputer to provide measurements of instantaneous velocity of both water and sediment, from which turbulence spectra, large scale turbulent structures, and the effect of suspended sediment on flow turbulence are being studied.

015-11627-870-36

MODELING OF MULTIPLE COOLING TOWER PLUMES

(*b*) U.S. Environmental Protection Agency.
(*c*) Dr. Robert C. Y. Koh.
(*d*) Theoretical applied research.
(*e*) A mathematical model is developed for prediction of plume behavior from multiple cooling towers with multiple cells. A general integral method based on the conservation of mass, momentum, energy and moisture fluxes is employed in the prediction scheme. The effects of ambient stratifications of temperature, moisture and wind are incorporated in the model. Comparison with laboratory data shows this model gives good prediction for the case of dry plumes. Verification of the model for wet plumes must await detailed comparison with field data.
(*f*) Completed.
(*h*) **Mathematical Model for Multiple Cooling Tower Plumes,** F. H. Y. Wu, R. C. Y. Koh, *W. M. Keck Lab. of Hydraulics and Water Resources, Rept. No. KH-R-37*, California Inst. of Tech., Pasadena, Calif. 91125, 61 pp., July 1977.

015-11628-220-54

SEDIMENT TRANSPORT MECHANICS DATABANK

(*b*) National Science Foundation.
(*c*) Dr. Robert C. Y. Koh.
(*d*) Theoretical.
(*e*) Assemble, verify and analyze the thousands of data points which are available in the literature on mechanics of sediment transport in alluvial streams. The bulk of the data is from laboratory investigations. It is recognized that the most crucial attribute of a databank is its accuracy. Thus each data point is critically examined from several points of view to ensure accuracy.

CALIFORNIA STATE UNIVERSITY, FULLERTON, Division of Engineering, Fullerton, Calif. 92634. Richard R. Brock, Chairman, Civil Engineering.

016-07978-820-33

HYDRODYNAMICS OF ARTIFICIAL GROUNDWATER RECHARGE

(*d*) Theoretical and field investigation; applied research.
(*e*) A continuing study to develop reliable methods for predicting the hydrodynamic behavior of recharge mounds beneath recharge ponds with emphasis on mound shape.
(*g*) One study in progress concerns perched recharge mounds on three separate semipervious layers below a square basin. The mathematical model allows for both confined and unconfined flow between the horizontal layers. Model will be used to compare with field results. Another study is for the case of recharge from a strip basin to an initially inclined water table. The Dupuit-Forchheimer theory is being used in this M.S. thesis.
(*h*) **Comment on Shapes of Steady State Perched Groundwater Mounds,** R. R. Brock, *Water Resources Research* **13**, 2, pp. 501-502, Apr. 1977.

CALIFORNIA STATE UNIVERSITY, LOS ANGELES, Department of Civil Engineering, 5151 State University Drive, Los Angeles, Calif. 90032. Dr. Young C. Kim, Professor and Chairman.

017-10024-870-54

OIL SLICK TRANSPORT ON SHOALING WATERS

(*b*) National Science Foundation Institutional Grant.
(*d*) Experimental and theoretical; applied research.
(*e*) The area of oil spread was measured in the laboratory and the predictable model was established in determining the spreading area of oil on coastal waters. The relationship between the oil slick and the Reynolds, Froude, and Weber numbers was examined and the influence of wind, currents, and waves on the spread area was investigated. The effects on the changes in water depth and the alteration of the net spreading coefficient on oil spreading capacity were also examined. Comparison between the existing field measurements and the laboratory work was made.
(*g*) There is a need for more scientifically controlled investigation on oil slick transport, particularly in the determination of true wind, waves, and current velocities. Further research is needed in developing more realistic solutions to the three-dimensional oil spreadinphenomena.
(*h*) **Oil Spreading on Coastal Waters,** Y. C. Kim, *Proc. 14th Intl. Conf. on Coastal Engrg.*, Copenhagen, June 1974.

017-10025-430-54

WAVE ENERGY ABSORBTION IN COASTAL STRUCTURES

(*b*) National Science Foundation.
(*d*) Experimental and theoretical; applied research.
(*e*) Model tests on perforated breakwater systems were carried out to evaluate the reflection coefficients and the reduction of incident wave pressures. The effect of perforating the bottom wall was studied to determine the extent of further reduction of pressure on the breakwater.
(*h*) **A Slit-Type Breakwater,** S. Nagai, S. Kakuno, *Proc. 15th Intl. Conf. Coastal Engrg.*, Hawaii, June 1976.

UNIVERSITY OF CALIFORNIA, Berkeley, College of Engineering, Department of Civil Engineering, Division of

Hydraulic and Sanitary Engineering, Berkeley, Calif. 94720.

018-08784-870-73

HYDRAULIC MODEL STUDY OF THE COOLING WATER SYSTEM PROPOSED FOR DIABLO CANYON FOR THE PURPOSE OF DETERMINING THE VALIDITY OF SUCH A MODEL TO PREDICT THE PROTOTYPE FOR VARIOUS OCEANIC CONDITIONS

(*b*) Pacific Gas and Electric Company.
(*c*) Professor R. L. Wiegel.
(*d*) Experimental.
(*e*) An undistorted 1:75 scale model of a 1,100 megawatt power plant has been designed, constructed and used to study the mixing characteristics of the system, based upon densimetric Froude modeling. Also, a separate study is being made in a different facility on the effect of the mixing and trajectory of the plume, of winds blowing over the water surface.
(*g*) Model studies are being made.
(*h*) **Nearshore Currents in the Vicinity of Diablo Canyon, California, 1967 and 1972-76,** J. Gosink, R. L. Wiegel, *Hyd. Engrg. Lab. Rept. HEL 27-3*, 168 pages, Aug. 1977.
Mixing of Horizontal Buoyant Surface Jet over Sloping Bottom, B. Safaie Khoram Daroudi, *Ph.D. Thesis*, Dept. of Civil Engrg., 198 pages, Aug. 1978.

018-10123-430-44

EARTHQUAKE LOADING ON LARGE OFFSHORE STRUCTURES IN DEEP WATER–A STUDY OF THE CORRELATION OF ANALYTIC AND PHYSICAL MODELS

(*b*) Sea Grant, NOAA and the State of California.
(*c*) Professor R. L. Wiegel.
(*d*) Experimental and theoretical; basic research.
(*e*) To provide information with which rational designs can be made of such structures as offshore oil storage tanks for high earthquake-risk areas. Physical tests will be made on the 20 ft by 20 ft earthquake simulator ("shaking table"), which will be "immersed" in a large water tank. A numerical model will be developed and compared with physical measurements.
(*h*) **A Laboratory Study of the Fluid-Structure Interaction of Submerged Tanks and Caissons in Earthquakes,** R. Clark Byrd, *Ph.D. Thesis*, Dept. of Civil Engrg., (also, *Univ. Calif. Earthquake Engrg. Research Center Report No. UCB/EERC-78/08*), 141 pages, June 1978.
Earthquake Excitation of Submerged Tanks and Caissons: A Correlation Study for Physical and Analytic Models, R. C. Byrd, F. Nilrat, *Proc. Offshore Tech. Conf.*, May 8-11, 1978, Houston, Tex., OTC 3110.
Earthquake Loading on Offshore Gravity Structures, R. C. Byrd, *Forefront, Research in the College of Engrg., Univ. Calif., Berkeley, 76/77*, pp. 100-103.
Report on Earthquake Loading on Large Offshore Structures in Deep Water–A Study for the Correlation of Analytic and Physical Models, R. J. Seymour, presented *U.S.-Japan National Resources Panel: Marine Facilities Panel Meeting*, 1 June 1977, Tokyo, Japan. Reproduced in the proceedings of the meeting, about November 1977 (in Japanese), pp. 116-117.

018-10124-860-61

THE INFLUENCE OF RIVER WATER QUALITY ON STORAGE RESERVOIR MANAGEMENT

(*b*) Water Resources Center, Univ. of California.
(*c*) Professors J. Imberger and H. B. Fischer.
(*d*) Experimental and theoretical; basic research.
(*e*) To demonstrate the usefulness of an exact description of the water motions when constructing a water quality model of a reservoir. The work proposed will validate and extend the recent model of Imberger, et al. (1976), and couple this with a water quality model. The more accurate description of the water motions and vertical and horizontal mixing is expected to yield consistently better water quality predictions.
(*h*) **Wind Mixing in Lakes,** R. H. Spigel, *Ph.D. Thesis*, Dept. of Civil Engrg., 274 pages, Dec. 1978.

018-10126-840-31

CONTROL OF IRRIGATION SYSTEMS USING WATER LEVEL SENSORS AND REAL-TIME COMPUTER SIMULATION

(*b*) U.S. Bureau of Reclamation, Denver.
(*c*) Professor J. A. Harder.
(*d*) Theoretical, field experimental.
(*e*) To establish the optimal means of automatically controlling irrigation check gate positions according to arbitrary water demands.

018-11259-420-54

DYNAMICS OF EDGE WAVES–AN EXPERIMENTAL AND ANALYTICAL STUDY

(*b*) National Science Foundation.
(*c*) Professor J. L. Hammack, Jr.
(*d*) Experimental and theoretical; basic research.
(*e*) Experimental facilities are being developed to enable direct generation of Stokes edge waves on beaches of varying slopes. Measurements of time periodic waves will be compared to previous theoretical results. Evolution of nonlinear edge wave systems will be studied.

018-11260-420-20

EXPERIMENTAL SOLITON WAVES

(*b*) Office of Naval Research.
(*c*) Professor J. L. Hammack, Jr.
(*d*) Experimental; basic research.
(*e*) Experimental facilities have been developed which permit the generation of deep water solitons–finite amplitude non-dispersive wave packets. The three-dimensional stability of these waves and their viscous decay in the laboratory is being studied.

018-11261-020-54

PREDICTIVE ABILITIES OF SURFACE WATER FLOW AND TRANSPORT MODELS

(*b*) National Science Foundation and Environmental Protection Agency.
(*c*) Professor H. B. Fischer.
(*d*) Symposium on applied research.
(*e*) A symposium will be held in Berkeley in August 1980, at which 12 invited speakers will present the state-of-the-art of surface water flow and transport modeling. The presentations will be published as a proceedings.

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CALIFORNIA, UNIVERSITY OF AT BERKELEY, Lawrence Berkeley Laboratory **(see Lawrence Berkeley Laboratory Listing).**

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UNIVERSITY OF CALIFORNIA, DAVIS, Department of Land, Air and Water Resources, Davis, Calif. 95616. L.O. Myrup, Chairman.

019-10078-820-54

MECHANISM OF FROST HEAVING IN EMBANKMENTS

(*b*) National Science Foundation.
(*c*) J. N. Luthin and G. S. Taylor.
(*d*) Experimental and computer model; basic research.
(*e*) Experiments will be conducted on the freezing of soil. Heat and moisture transfer will be measured. Soil characteristics will be determined. The experimental data will be used to verify a computer model of the process. The

model will then be used to analyze the engineering design of embankments.

(*g*) Computer model has been developed using a finite difference scheme.

(*h*) **A Model for Coupled Heat and Moisture Transfer During Soil Freezing,** *Canadian Geotechnical Journal 15:4:548-555.*

019-11547-820-33

REGIONAL GROUNDWATER MANAGEMENT

(*b*) University of California Water Resources Center; Office of Water Research and Technology; California State Energy Resources Conservation and Development Commission; South Tahoe Public Utility District.

(*c*) Dr. Verne H. Scott.

(*d*) Theoretical and field investigation; applied research; for Master's and Ph.D. theses.

(*e*) Research has progressed in four areas: 1) an assessment of brackish groundwater for power plant cooling in California, including impacts of withdrawal; 2) development of a two-dimensional, finite element model of a regional groundwater basin to analyze confined and unconfined flow in response to varying demands and hydrologic conditions; 3) a hydrologic evaluation of groundwater resources in a sub-alpine lake-aquifer system; 4) development of mathematical models to obtain optimal operating policies in a surface-ground water conjunctive use system based on minimum cost or energy; and 5) development of a program to maximize net benefits from groundwater irrigation supply systems.

(*g*) A summary report on brackish groundwater for power plant cooling has been prepared; a two-dimensional finite element groundwater model has been completed and verified; a summary report on groundwater resources in a sub-alpine lake-aquifer system has been prepared; and a model of a small regional conjunctive use system has been prepared and operating policies based on minimum cost and energy have been compared.

(*h*) **Brackish Ground Water for Power Plant Cooling in California,** V. H. Scott, J. C. Scalmanini, K. A. Popko, *Water Science and Engineering Paper 2008*, Univ. of Calif., Davis, 115 pages, Nov. 1978.

Water Wells and Pumps: Their Design, Construction, Operation and Maintenance, V. H. Scott, J. C. Scalmanini, *Division of Agricultural Sciences Bulletin 1889*, Univ. of Calif., 51 pages, May 1978.

Groundwater Resources of the South Tahoe Public Utility District, V. H. Scott, J. C. Scalmanini, R. A. Matthews, *Water Science and Engineering Paper 2007*, Univ. of Calif., 92 pages, May 1978.

Groundwater Basin Modeling Using the Finite Element Method–Yolo County Case Study, O. A. Bamgboye, thesis submitted in partial satisfaction of the requirements for M.S. Degree, Univ. of Calif., Davis, 126 pages, 1978.

019-11548-820-65

URBAN ARTIFICIAL GROUNDWATER RECHARGE FACILITIES–DESIGN AND OPERATION

(*b*) Santa Clara Valley Water District.

(*c*) Dr. Verne H. Scott.

(*d*) Experimental and field investigation; applied research, design and operation.

(*e*) Assessment and evaluation of the design, operation, and maintenance of groundwater recharge with the goal of defining design and operational parameters that will improve recharge efficiencies particularly in an urban setting.

(*g*) Design and operational parameters have been defined: size, shape, depth, orientation, construction, and landscaping of ponds; design and completion of injection wells; and design and operational considerations relative to recharge site selection and evaluation, pretreatment of recharge water, control of clogging in ponds and wells, wet/dry infiltration cycles, water quality, and multipurpose use of recharge facilities. A summary report is in preparation.

019-11549-840-60

INTERRELATIONSHIP AMONG IRRIGATION, DRAINAGE AND SALINITY CONTROL

(*b*) California Agricultural Experiment Station.

(*c*) J. N. Luthin, and B. Hanson.

(*d*) Field investigation, applied research.

(*e*) Measurements will be made in the Tulare Lake Basin, Calif., on parameters affecting drainage, irrigation and salt control. A predictive model will be developed that integrates the field information.

019-11550-070-00

MODELING MOVEMENT OF CONTAMINANTS IN GROUNDWATER

(*b*) Water Resources Center, University of California.

(*c*) Professors M. A. Marino and V. H. Scott.

(*d*) Theoretical; basic and applied research.

(*e*) Numerical simulation of contaminant transport in subsurface systems involves the simultaneous or sequential solution of the flow and mass transport equations subject to appropriate initial and boundary conditions. Both finite difference and finite element techniques have been used to solve these equations. A two-dimensional finite element model has been developed that simulates the movement and depth distribution of a dissolved chemical substance in a recharged stream-aquifer system. The model is appropriate for investigating the effects of possibly contaminated recharge effluent on the quality and quantity of groundwater supplies.

(*f*) Completed.

(*g*) See publications.

(*h*) **Modeling Movement of Contaminants in Groundwater Systems,** V. H. Scott, M. A. Marino, *California Water Resources Center Report No. 37*, p. 49, 1976.

Numerical Simulation of Contaminant Transport in Subsurface Systems, M. A. Marino, *Advances in Groundwater Hydrology*, ed. by Z. A. Saleem, Amer. Water Resources Assoc., pp. 113-129, Sept. 1976.

A Finite Element Model of Contaminant Movement in Groundwater, G. Cabrera, M. A. Marino, *Water Resources Bulletin, AWRA* **12**, 2, pp. 317-335, Apr. 1976.

Flow Against Dispersion in Nonadsorbing Porous Media, M. A. Marino, *J. of Hydrology* **37**, pp. 149-158, Apr. 1978.

019-11551-840-00

INVESTMENT CRITERIA FOR INSTALLING SUBSURFACE DRAINAGE SYSTEMS

(*b*) Water Resources Center, University of California.

(*c*) Professors M. A. Marino and G. L. Horner.

(*d*) Basic and applied research.

(*e*) A methodology for evaluating the profitability of alternative drain spacings and depths for given physical and economic conditions has been developed. Equations relating annual profit to drain spacing and depth have been derived. Drainage investment appears to be the most profitable at spacing-depth combinations which maximize or come close to maximizing crop yields. In addition, a transient two-dimensional numerical simulation model has been developed to quantitatively examine both saturated and unsaturated flow toward subsurface drains. It can be used to determine the flow and the depth of water levels between subsurface drains, and the size, spacing, and depth of drains for various field situations. Another numerical simulation model has been developed to include the effect of salinity of irrigation water in the flow toward drains.

(*f*) Completed.

(*g*) See publications.

(*h*) **Investment Criteria for Installing Subsurface Drainage Systems,** M. A. Marino, G. L. Horner, *California Water Resources Center Report No. 42*, p. 48, 1977.

On-Farm Drainage Investment Decision Criteria in the Panoche Water District, J. C. Fitz. Thesis submitted in partial satisfaction of the requirements for M.S. Degree, Univ. of Calif., Davis, 108 pages, Oct. 1977.

A Galerkin-Finite Element Simulation of Solute Transport in Subsurface Drainage Systems, M. A. Marino, G. B. Matanga, *Finite Elements in Water Resources*, ed. by C. A. Brebbia, W. G. Gray, G. F. Pinder, Pentech Press, London, pp. 1.51-1.67, July 1978.

Finite-Element Simulation of Solute Transport in Saturated-Unsaturated Drainage Systems, M. A. Marino, *Tech. Completion Rept., Water Resources Center Project UCAL-WRC-W-521*, 28 pages, Aug. 1978.

Investment Criteria for Installing Subsurface Drainage Systems, M. A. Marino, G. L. Horner, *Calif. Water Resources Center Rept. No. 43*, p. 28, Dec. 1978.

019-11552-870-05

MASS TRANSPORT AND DISTRIBUTION OF CONTAMINANTS IN POROUS MEDIA

(*b*) Agricultural Research Service, U.S. Department of Agriculture.
(*c*) Professor M. A. Marino.
(*d*) Theoretical; basic and applied.
(*e*) Analytical solutions have been developed that describe the mass transport and distribution of contaminants in saturated porous media. Some of the solutions are applicable for analyzing dispersion problems in finite nonadsorbing media while others include simultaneous dispersion and adsorption of a solute. Different forms for the solutions are given to facilitate the computation of particular values. The solutions are useful for quantitatively predicting the possible control of spreading of poor-quality water by freshwater flow. Numerical simulation models also have been developed to analyze the movement and distribution of dissolved chemical substances in saturated-unsaturated porous media. Solutions provided by these models are useful in making quantitative evaluations of schemes to prevent and control groundwater contamination and quantitative predictions of spatial and temporal changes in groundwater quality.
(*g*) See publications.
(*h*) **Longitudinal Dispersion in Saturated Porous Media,** M. A. Marino, *J. Hydraulics Div., ASCE* **101**, HY1, pp. 151-157, Jan. 1974.

Numerical and Analytical Solutions of Dispersion in a Finite, Adsorbing Porous Medium, M. A. Marino, *Water Resources Bull., AWRA* **10**, 1, pp. 81-90, Feb. 1974.

Distribution of Contaminants in Porous Media Flow, M. A. Marino, *Water Resources Research* **10**, 5, pp. 1013-1018, Oct. 1974.

Models of Dispersion in a Granular Medium, M. A. Marino, *J. Hydrology* **23**, pp. 313-318, Dec. 1974.

Mass Transport of Solutes in Saturated Porous Media, M. A. Marino, *Water Sci. and Engrg., Paper No. 2003*, 44 pages, July 1975.

Solute Transport in a Saturated-Unsaturated Porous Medium, M. A. Marino, *Modeling, Identification and Control in Environmental Systems*, ed. by G. C. Vansteenkiste, North-Holland Publ. Co., Amsterdam, pp. 269-281, 1978.

Flow Against Dispersion in Adsorbing Porous Media, M. A. Marino, *J. Hydrology* **38**, pp. 197-205, July 1978.

019-11553-820-05

NITROGEN TRANSPORT IN SOIL SYSTEMS

(*b*) Agricultural Research Service, U.S. Department of Agriculture.
(*c*) Professor M. A. Marino.
(*d*) Theoretical; basic and applied.
(*e*) The transport of nitrogeneous materials in soil systems plays an important role in both production and the quality of surface and groundwater supplies. Mathematical models have been developed for predicting the transport and distribution of nitrogen compounds in soils. They take into account the concentration of nitrogen gas in the soil as a result of denitrification and its diffusion to the atmosphere. By obtaining solutions to the models we can examine their applicability to nitrogen transformations measured in soils under a series of environmental conditions.
(*g*) See publications.
(*h*) **Simulation Models of Nitrogen Transport in Soil Systems,** M. A. Marino, *Proc. Conf. on Modeling of Environmental Systems, Intern. Fed. for Inform. Processing*, ed. by T. L. Kunii and Y. Kaya, Tokyo, Japan, pp. 85-88, Apr. 1976.

Mathematical Model for Simulating Soil Moisture Flow Considering Evapotranspiration, A. Afshar, M. A. Marino, *Water Sci. and Engrg., Paper No. 6002*, 100 pages, Sept. 1976.

Simultaneous Transport of Nitrate and Gaseous Denitrification Products in Soil, D. E. Rolston, M. A. Marino, *Soil Sci. Soc. of America J.* **40**, 6, pp. 860-865, Nov.-Dec. 1976.

Model for Simulating Soil Water Content Considering Evapotranspiration, A. Afshar, M. A. Marino, *J. Hydrology* **37**, pp. 309-322, May 1978.

019-11554-820-05

WATER TABLE FLUCTUATIONS INDUCED BY PERCOLATION

(*b*) Agricultural Research Service, U.S. Department of Agriculture.
(*c*) Theoretical; basic and applied.
(*e*) The development and solution of mathematical models capable of predicting the rise and fall of the water table in aquifer systems in response to deep percolation and stream stage fluctuation are of practical importance in the evaluation and management of groundwater resources and in the study of irrigation and drainage problems. Numerous mathematical models have been developed which describe transient flow in unconfined aquifers receiving deep percolation. The models take into account different types of variation of the percolation rate, different sizes and shapes of areas over which the percolation takes place, and various hydraulic and geometric parameters of the underlying aquifer. The solutions are useful in te evaluation of quantitative and qualitative changes in aquifer systems due to natural or artificial recharge. In addition, from the solutions presented we can estimate the feasibility of recharge projects and make recommendations on the duration of recharge operations.
(*f*) Completed.
(*g*) See publications.
(*h*) **Water-Table Fluctuation in Semipervious Stream-Unconfined Aquifer System,** M. A. Marino, *J. Hydrology* **19**, pp. 43-52, May 1973.

Water-Table Fluctuation in Response to Recharge, M. A. Marino, *J. Irrigation and Drainage Div., ASCE* **100**, IR2, pp. 117-125, June 1974.

Growth and Decay of Groundwater Mounds Induced by Percolation, M. A. Marino, *J. Hydrology* **22**, pp. 295-301, Aug. 1974.

Rise and Decline of the Water Table Induced by Vertical Recharge, M. A. Marino, *J. Hydrology* **23**, pp. 289-298, Dec. 1974.

Digital Simulation Model of Aquifer Response to Stream Stage Fluctuation, M. A. Marino, *J. Hydrology* **25**, pp. 51-58, Apr. 1975.

Artificial Groundwater Recharge, I, Circular Recharging Area, M. A. Marino, *J. Hydrology* **25**, pp. 201-208, May 1975.

Artificial Groundwater Recharge, II, Rectangular Recharging Area, M. A. Marino, *J. Hydrology* **26**, pp. 29-37, July 1975.

Response of Unconfined Aquifer Systems to Deep Percolation, M. A. Marino, *Water Sci. and Engrg., Paper No. 2004*, 39 pages, July 1975.

Mathematical Models of Artificial Recharge Systems, M. A. Marino, *Water Sci. and Engrg., Paper No. 2005*, 59 pages, July 1975.

Dynamic Response of Aquifer Systems to Localized Recharge, G. Cabrera, M. A. Marino, *Water Resources Bulletin, AWRA* **12**, 1, pp. 49-63, Feb. 1976.

Groundwater Storage Considerations: Alternative Courses of Action, M. A. Marino, *Proc. 11th Biennial Conf. on Groundwater, Calif. Water Resources Center Rept. 41*, pp. 160-161, 1977.

019-11555-840-00

PLANNING OF IRRIGATION SYSTEMS MANAGEMENT

(*c*) Professor M. A. Marino.
(*d*) Theoretical and field; basic and applied research.
(*e*) Irrigation programs, specified in terms of dates and depths of irrigation, are developed for various crops. The information contained in the irrigation programs for each crop is applied in an area-allocation model to determine a cropping pattern for the crops. The area-allocation model maximizes gross margin from yields of crops under consideration subject to total water supply, maximum amount of water that can be delivered for irrigation purposes on any date of irrigation, and irrigation labor. Results from the model include cropping pattern, gross margin, total irrigation depth on each data of irrigation, total irrigation labor, and crop yield. For a finite or infinite planning horizon, an interseasonal model is developed for determining an irrigation policy in terms of leaching and seasonal irrigation depths.
(*f*) Completed.
(*g*) See publications.
(*h*) **Application of Optimization and Simulation Techniques to Irrigation Management,** G. B. Matanga, M. A. Marino, *Water Sci. and Engrg., Paper No. 5003,* 237 pages, Aug. 1977.
Preseason Irrigation Scheduling by Discrete Differential Dynamic Programming, G. A. Robb, M. A. Marino, *Water Sci. and Engrg., Paper No. 5004*, 78 pages, Oct. 1977.
Irrigation Planning, 1, cropping Pattern, G. B. Matanga, M. A. Marino, *Water Resources Research*, to be published in 1979.
Irrigation Planning, 2, Water Allocation for Leaching and Irrigation Purposes, G. B. Matanga, M. A. Marino, *Water Resources Research*, to be published in 1979.

019-11556-860-00

OPTIMAL CAPACITY EXPANSION OF DESALINATION PLANTS

(*c*) Professor M. A. Marino.
(*d*) Basic and applied research.
(*e*) A mathemtical programming model is structured to find the optimal time and capacity expansion path of desalination plants and storage tanks for a community which depends on desalination as its sole, or major, water supply source. The objective is to determine the least costly combination of sizes and times of installation (of both desalting plants and storage tanks) which can meet a rising water demand over a finite planning horizon. The optimality criterion used in the model is based on two major economic elements: the economies of scale inherent in such facilities and the time-value of money represented by the interest rate, the former favoring large capacities and the latter small capacities.
(*f*) Completed.
(*g*) See publications.
(*h*) **The Optimal Multistage Capacity-Expansion of Desalination Plants and Storage Tanks,** H. N. Rajhi, M. A. Marino, *Water Sci. and Engrg., Paper No. 5002*, 94 pages, Apr. 1975.
On the Capacity Expansion of Desalination Plants and Storage Tanks, H. N Rajhi, M. A. Marino, *Water Resources Bulletin, AWRA* **12,** 3, pp. 481-500, June 1976.

019-11696-200-60

EFFECTS OF WIND ON OPEN CHANNEL FLOWS

(*b*) California Department of Water Resources, Sacramento, California.
(*c*) Dr. Jaime Amorocho.
(*d*) Experimental; basic research.
(*e*) Wind blowing over open channels can cause significant changes in the water surface profile (set up) and produce wind waves on the surface. Relationships between wind shear and wind speed were determined for laboratory data and field data. Data were obtained from: a) wind profile measurements, b) water surface setup data, c) measurements of Reynolds stresses in the air flow over the water in the field. Data from numerous other investigations were included in the analysis.
Wind shear was specified as a function of wind speed using the shear velocity u_*, rather than following the common practice of using a wind shear coefficient C_z. This proved to be a superior way of presenting the wind shear at low wind speeds. An evaluation of the variances of u_* and C_z indicated that the relative variance of u_* at low wind speed is much smaller than that for C_z, and the relationship between wind shear and wind speed could be more clearly defined.
(*f*) Completed.
(*g*) Analysis of data from this study as well as data from a number of other investigations indicates that a large portion of the difficulties encountered in the part in establishing the relationship between the wind shear coefficient C_z and the wind speed U_z can be attributed to computationally induced scatter of the data. However, plots of the shear velocity u_* against U_z reveal clear trends which show that three regions exist in the development of the wind shear stress: a) a lower region in which the wind waves have not begun to break; b) a transitional region, after the onset of breakers for C_z varies nonlinearly with U_z; and c) a limiting region for which C_z tends again towards a constant value and corresponds to a condition of breaker saturation. A single general equation to express C_{10} as a function of U_{10} is proposed which agrees with the above findings. It is shown that in contrast with the perception of previous investigators, Charnock's coefficient $\alpha = Z_0 g/u_*^2$ is not a constant anywhere in the range of wind velocities $0 < U_{10} < 40$ m/s.
(*h*) **A New Evaluation of the Wind Stress Coefficient Over Water Surfaces,** J. Amorocho, J. J. DeVries, submitted to *J. Geophys. Res.*, 1979.
Wind Stress in Open Channel Flow, J. J. DeVries, J. Amorocho, submitted to *ASCE J. Waterways and Harbors Division*, 1979.

019-11697-810-31

CONTROL OF EVAPORATION FROM SNOW FIELDS

(*b*) U.S. Bureau of Reclamation, Department of the Interior.
(*c*) Dr. Jaime Amorocho.
(*d*) Experimental, theoretical, and field investigation; applied and developmental.
(*e*) The project involves a careful study of snowpack evolution as a component of hydrologic systems, and of the means of modifying these evolutionary processes by controlling evaporation and increasing melt.
A complex mathematical model of the snowpack evolution processes has been developed at U. C. Davis. For the development of this model, published data on snowpack variables obtained by the U.S. Forest Service at the Central Sierra Snow Laboratory, as well as other published meteorological and climatological information were used. Partial tests of the model have been performed with data gathered at a special installation constructed in the Andes Mountains in Chile under a cooperative agreement between the University of California and the University of Chile. These mathematical modeling techniques have the ultimate aim of perfecting reliable procedures for predetermining the effects of alternative snowpack management strategies as a basis for regional water resources systems operations. To evaluate the various functions and parameters entering the latest version of the model, it is considered essential to obtain data on a snowpack accumulated naturally. For this purpose, a special

study was conducted at the Central Sierra Snow Laboratory, designed specifically for recording these functions and parameters, and utilizing a large snowmelt lysimeter and other instrumentation for data acquisition.

(*g*) The effects of evaporation modifiers on the evolution of snowpacks have been studied under controlled conditions by means of a large snow lysimeter which incorporates many unusual features and is the first of its kind in the world. Detailed studies of snowpack evolution can be conducted simultaneously in the two chambers of the instrument. The snow received in one of the chambers received treatment; the other was used as control. The most unique feature of the instrument is that it effectively separates the snow under test from the surrounding pack by a system of moving walls which extend vertically from the ground as snow is accumulated, without protruding above the snow surface. The walls also retract as the snow becomes consolidated, or compacted, as well as when it melts gradually in the spring, so that a clean sweep of undisturbed surface is maintained between the test regions and the surroundings. This permits following closely the conditions of the natural pack, while preventing crossflow of melt water. The scheme permits very accurate measurements of snowmelt rates by means of specially designed devices. Continuous profiles of snowpack variables such as density, temperature and water content can be followed spatially be means of special thermistor arrays and a moving gamma-ray snow gage which scans the snow in the vertical. These profiles are recorded automatically and repeated at programmed intervals to follow the evolution of the entire pack complex. These measurements, in conjunction with recordings of pertinent meteorological variables such as solar radiation, snow and rainfall, wind velocities, air temperatures, etc., permit a thorough analysis of the treated and untreated snow to gain knowledge on the mechanisms of snow evolution and effectiveness of the treatments.

(*h*) **Snowmelt Lysimeter,** K. Thompson, J. DeVries, J. Amorocho, *Proc., Western Snow Conference 1974*, Coronado, Calif., Apr. 1975.
Operating Manual for a Snowmelt Lysimeter, K. Thompson, S. Buer, J. DeVries, J. Amorocho, *Water Science and Engrg. Paper No. 3009*, Nov. 1977.

019-11698-300-60

DELTA DIVERSION FACILITIES FOR THE CALIFORNIA WATER PROJECT

(*b*) California Department of Water Resources, Sacramento, California.
(*c*) Dr. Jaime Amorocho.
(*d*) Experimental; developmental.
(*e*) Hydraulic model studies are being made for the design of intake and fish screen structures for large-scale diversion of water for the California Water Project from the Sacramento River at the Peripheral Canal Intake. Two general problems are being studied: 1) design and location of the intake from the river to minimize diversion of sediment into the intake and to avoid erosion and deposition problems in the river, and 2) development of fish screening facilities for protecting marine life at the intakes to lessen the environmental effects of the water diversions.
A distorted-scale laboratory model of 5.5 miles of the river has been tested and two general types of diversion schemes have been evaluated. The first scheme has the fish screens along the existing river bank (over a length of one mile); the second, an off-stream channel parallel to the river is used to produce a carefully regulated velocity environment from which the flow is diverted into a canal through fish screens.
Sediment studies have been made in this model, as well as general description and evaluation of flow patterns. Further studies will be made in an undistorted 1:50 scale model of just the fish screen structures and adjacent river.
(*g*) The "off-river" intake proved superior to the scheme in which the fish screens were located on the river bank from the standpoint of less problems with sediment and the ability to control velocities in the vicinity of the fish screens to the range most suitable for effectively directing fish away from the screens. The location of the diversion point was selected on the basis of minimum bed load sediment removed with the water flow. Data for the design and operation of the 1:50 scale model were obtained.
(*h*) **Peripheral Canal Intake Studies. I. Distorted Scale Channel Model,** W. Hartman, J. Amorocho, J. J. DeVries, *Water Science and Engrg. Paper No. 1064*, June 1979.

UNIVERSITY OF CALIFORNIA, DAVIS, Department of Mechanical Engineering, Davis, Calif. 95616. Professor Charles W. Beadle, Department Chairman.

020-10834-220-50

AEOLIAN SURFACE FLUX RATES ON EARTH AND MARS

(*b*) NASA-Ames Research Center.
(*c*) Professor Bruce R. White.
(*d*) Experimental and theoretical, basic research, M.S. and Ph.D. theses.
(*e*) The planet Mars has large amounts of surface material moved during its frequent dust storms. These dust storms account for huge quantities of material movement in comparison to terrestrial counterparts. The increased material movement is not fully understood, although some of it can be accounted for by the difference in gravity between the two planets. However, wind erosion on Mars is still substantial considering the gravity difference; thus there are additional changes that enhance the aeolian transport of surface material on Mars. One of the most important of these is the change in atmospheric pressure on Mars; the pressure is only a few percent of the pressure on Earth. The purpose of the proposed study is to learn more about the aeolian transport of surface material through a series of wind-tunnel experiments in a low-pressure chamber.
(*g*) The aeolian transport of surface material on the planet Mars is estimated from results of low-pressure wind-tunnel testing and theoretical considerations. A semi-empirical relation is developed that will estimate the total amount of surface material moving in aeolian saltation, suspension, and surface traction. The estimated total mass movement of surface material per unit width-time on the surface of Mars is $q = 2.61\ \rho(V_* - V_{*_t})(V_* + V_{*_t})^2/g$ (gm/cm-sec) where ρ is the density of the atmospheric gas, g is the acceleration due to the gravity, and V_* and V_{*_t}, are the friction speed and saltation threshold friction speed, respectively. A flat surface composed of particles of nearly uniform size is assumed. A change in the mean particle size changes the threshold friction speed V_{*_t}.
(*h*) **Low-Reynolds-Number Turbulent Boundary Layers,** B. R. White, *Symposium on Turbulent Boundary Layers, ASME*, Niagara Falls, N.Y., June 18-20, 1979.
Dust Storms on Mars: Considerations and Simulations, R. Greeley, B. R. White, J. B. Pollack, J. D. Iversen, R. N. Leach, *NASA Technical Memorandum 78423*, Dec. 1977.
Dust Storms on Mars: Considerations and Simulations, R. Greeley, B. R. White, J. B. Pollack, J. D. Iversen, R. N. Leach, *Desert Dust: Origin, Characteristics, and Effect on Man: Dust Storms on Mars, Proc. Amer. Assoc. for the Advancement of Science*, Denver, Feb. 1977.
Wind Transport Rates on Mars, B. R. White, *J. Geophysical Research*, in press, 1979.

020-10835-050-88

LIQUID JET STABILITY STUDIES

(*b*) Lawrence Livermore Laboratory, Livermore, California.
(*c*) Professor Myron A. Hoffman.
(*d*) Experimental and theoretical study, applied research, M.S. and Ph.D. theses.
(*e*) Studies of hollow annular, solid cylindrical, and planar sheet water jets have been conducted with forced-vibration of the nozzles to determine jet instability and breakup

parameters. Tests have been run both at 1 atm and 0.2 atm.

(*g*) The planar sheet jets have displayed unexpected resistance to breakup even when the feed nozzles were subjected to relatively large amplitude forced vibrations. Two nonlinear regimes have been identified, and a theory has been developed which predicts the nonlinear results in one of the regimes very well.

(*h*) **Annular Liquid Jet Experiments,** *Final Report No. 3.*
Experimental Investigation of the Stability of Liquid Sheet Jets, *Final Report No. 4.*

UNIVERSITY OF CALIFORNIA, SAN DIEGO, Scripps Institution of Oceanography, (see SCRIPPS INSTITUTION OF OCEANOGRAPHY listing).

UNIVERSITY OF CALIFORNIA, SANTA BARBARA, College of Engineering, Department of Chemical and Nuclear Engineering, Santa Barbara, Calif. 93106. Dr. Dale E. Seborg. Department Chairman.

021-10111-020-00

TURBULENT CONVECTIVE TRANSPORT

(*c*) Professor O. C. Sandall or O. T. Hanna.

(*d*) Applied research; theoretical and experimental; Master's and Doctor's theses.

(*e*) Studies of turbulent heat and mass transfer for small diffusivities; non-Newtonian and chemical reaction effects.

(*g*) Successful correlation of theory and experiment has been achieved for fully developed flow conditions.

(*h*) **Heat Transfer in Turbulent Pipe Flow for Liquids Having a Temperature Dependent Viscosity,** O. T. Hanna, O. C. Sandall, *ASME J. Heat Transfer* **100,** 224 (1978).
Large Schmidt Number Mass Transfer in Turbulent Pipe Flow, O. C. Sandall, O. T. Hanna, *AIChE J.* **25,** 190 (1979).

UNIVERSITY OF CALIFORNIA, SANTA BARBARA, Department of Geography, Santa Barbara, Calif. 93106.

022-11721-810-50

CALIBRATION OF SATELLITE DATA FOR INPUT TO DISTRIBUTED PARAMETER HYDROLOGIC MODELS

(*b*) National Aeronautics and Space Administration, Earth Resources Survey Program, Grant No. NSG-5262.

(*c*) Jeff Dozier, Assistant Professor.

(*d*) Experimental and field investigation; applied research; contribution from Master's and Doctoral theses.

(*e*) The project investigates ways in which atmospheric, surface emissivity, and terrain effects can be calibrated from satellite data for use as input for distributed parameter hydrologic models. This study consists of two parts: 1) we derive the parameters necessary to drive an energy balance snowmelt model by using digital image data from Landsat-2, Landsat-3, AEM-A, and NOAA meteorological satellites, using a data collection platform in a remote location within the study area, a series of accessible data collection stations at several elevations from 2000 m to 3500 m, and extensive field measurements at intervals during the snow season; 2) we use the snowfield data collection system to calibrate satellite data for input into distributed parameter models other than snowmelt models. Specifically, we will couple a modified lumped parameter streamflow forecasting model to the distributed parameter snowmelt model.

(*h*) **An Approach Toward Energy Balance Simulation Over Rugged Terrain,** J. Dozier, S. I. Outcalt, *Geographical Analysis* **11,** 65-85, 1979.
A Solar Radiation Model for a Snow Surface in Mountainous Terrain, J. Dozier, *Proc. Modeling of Snow Cover Runoff*, S. C. Colbeck, M. Ray, Editors, Hanover, N H.: U.S. Army Cold Regions Research and Engineering Laboratory, pp. 144-153, 1979.
A Clear-Sky Longwave Radiation Model for Remote Alpine Areas, D. Marks, J. Dozier, *Archiv fur Meteorologie Geophysik und Bioklimatologie*, Serie B. 1979 (in press).

022-11722-810-44

USE OF ENVIRONMENTAL SATELLITE DATA FOR INPUT TO ENERGY BALANCE SNOWMELT MODELS

(*b*) National Oceanic and Atmospheric Administration, Grant No. 4-08-Mo.

(*c*) Jeff Dozier, Assistant Professor.

(*d*) Experimental and field investigation; applied research; contribution from Master's and Doctoral theses.

(*e*) Environmental satellite data are used, in combination with field measurements and computer modeling, to derive a number of input parameters for an energy balance snowmelt model, so that it can be utilized over large, mountainous watersheds. We are investigating the possibility of generating the necessary inputs for: 1) solar radiation in clear and cloudy weather, 2) longwave radiation in clear and cloudy weather, and 3) wind speeds. We are also investigating the feasibility and potential use of mapping isothermal snow cover. Our study area consists of the watersheds of the Kern and Kings Rivers in the southern Sierra Nevada. Our results will lead to development of techniques for more accurate snowmelt runoff forecasting, which would be useful for flood prediction and agricultural reservoir management.

(*h*) **A Solar Radiation Model for a Snow Surface in Mountainous Terrain,** J. Dozier, *Proc. Modeling of Snow Cover Runoff*, S. C. Colbeck, M. Ray, Editors, Hanover, N.H.: U.S. Army Cold Regions Research and Engineering Laboratory, pp. 144-153, 1979.
A Clear-Sky Longwave Radiation Model for Remote Alpine Areas, D. Marks, J. Dozier, *Archiv for Meteorologie Geophysik und Bioklimatologie*, Serie B, 1979 (in press).

022-11723-810-33

COUPLING AN ENERGY BALANCE SNOWMELT MODEL TO A STREAMFLOW MODEL, GRANT NO. UCAL-W-546

(*b*) Water Resources Center, University of California, Davis, Calif. 95616.

(*c*) Jeff Dozier, Assistant Professor.

(*d*) Experimental and field investigation; applied research; contribution from Master's and Doctoral theses.

(*e*) Conventional snowmelt models based on regression analysis fail to adequately predict snowmelt runoff under extreme meteorological conditions. We are developing an energy balance snowmelt model for use in the southern Sierra Nevada which will more accurately predict melt rates under extreme conditions; predictions are based upon daily monitoring of specific meteorological variables. This model must be: 1) applied over an entire drainage basin, and 2) coupled to an existing or modified streamflow model. This project is directed toward coupling a snowmelt model to a flow model.

UNIVERSITY OF CALIFORNIA, SANTA BARBARA, Geography Remote Sensing Unit, Santa Barbara, Calif. 93106.

023-10836-710-60

IRRIGATED LANDS ASSESSMENT FOR WATER MANAGEMENT: APPLICATIONS PILOT TEST

(*b*) Remote Sensing Research Program–University of California, Berkely cooperative with the California Department of Water Resources.

(*c*) Larry Tinney, Project Manager.

(*d*) Experimental investigation, applied research, operation.

(*e*) Identification of California's approximately 10 million acres of irrigated land (which accounts for 85 percent of the state water use) using a statewide, multistage, multidate sample based on manual interpretation of Landsat imagery in conjunction with low altitude photography and field checked data; major regional demonstration of digital image processing during the first year in the Sacramento Valley and the Delta region to identify irrigated cropland, followed by a statewide digital effort as a part of next year's efforts.

(*h*) **An Inventory of Irrigated Lands Within the State of California Based on Landsat and Supporting Aircraft Data,** L. Wall, D. Noren, J. M. Sharp, S. Titus, R. N. Colwell, *Final report for Contract NAS 5-20969*, 1977.
An Inventory of Irrigated Lands for Selected Counties Within the State of California Based on Landsat and Supporting Aircraft Data, *Final report for NASA Contract NSG 2207*, 1977.

023-10837-810-65

WATERSHED RUNOFF PREDICTIONS USING LANDSAT DIGITAL DATA

(*b*) Kern County Water Agency, Bakersfield, Calif. NASA Grant NSG-7220.
(*c*) Fredrick C. Mertz, Project Manager.
(*d*) Applied, Master's.
(*e*) Landsat digital data is utilized to produce a vegetation categorization map. These vegetation data are then input to the Soil Conservation Service (SCS) runoff model for prediction of peak flows. The Kern County Water Agency (KCWA) uses these runoff prediction data for policy decisions concerning flood related issues. Conventional vegetation collection methods are expensive and time consuming. The Landsat approach being investigated provides a timely and relatively inexpensive alternate data source.
(*g*) To date, only small geographic areas have been completed, but initial results are favorable.

023-10838-870-22

SAMPLING-INTENSIVE LOW-SPEED CRUISE FOR OIL SLICK-VESSEL INTERACTION

(*b*) Civil Engineering Lab., Naval Construction Battalion Center, Port Hueneme, Calif. Contract N-62583/78-M-R 132 P0002.
(*c*) Mike Wilson, Project Manager, GRSU, Mr. Karl Rocker, Contract Monitor, L42, Civil Engrg. Lab, NCBC, Port Hueneme, Calif. 93043.
(*d*) Field investigation, design.
(*e*) Objective is to track the location of surface oil in the path of a vessel engaged in low-speed oil recovery operations. Sea trials are conducted in natural oil seep areas of the Santa Barbara Channel, with the location and thickness of oil during the passage of a vessel documented by shipboard and aerial photography and surface oil samples.
(*g*) Data collected in conjunction with sea tests to determine the effects of vessels on surface oil slicks seem to indicate that vessel speed and direction in relation to swell height/direction and, to a lesser extent, wind speed/direction are the most significant factors to be considered in planning for maximum oil sorbent dispersal/recovery success. It has also been generally observed that a correlation exists between oil slick displacement and oil film thickness, given the same vessel, oceanographic and meteorological parameters.
(*h*) **Surface Oil Displacement By U.S. Coast Guard 82-Foot Cutters,** J. E. Estes, S. P. Kraus, R. W. Tennant, C. Hansen, University of California, Santa Barbara, California, (Jan. 1979).

023-10839-820-88

SOIL MOISTURE DETERMINATION USING MICROWAVE/INFRARED TECHNIQUES

(*b*) Jet Propulsion Laboratory, Pasadena, Calif. Contract JPL-955032.
(*c*) Dr. John E. Estes, Principal Investigator; Susan Atwater, Project Manager.
(*d*) Field investigation.
(*e*) A series of experiments were performed with JPL van-mounted microwave radiometers during May 1978 near Bakersfield, California, to investigate the use of microwave and infrared radiometric techniques for determining soil moisture. Observations were made of bare fields with varying moisture and temperature profiles and different degrees of surface roughness. Data consisting of surface and subsurface temperature measurements and soil samples analyzed for moisture content and bulk density were collected concurrently with the measurement of microwave and thermal infrared emissions and micrometeorological variables by JPL personnel. During the analysis phase of the project, the main intent of JPL researchers will be to evaluate the potential of a combined microwave-thermal infrared systems approach for the remote detection of soil moisture.

023-10840-870-30

ANALYSIS OF SEASAT-A SAR DATA FOR THE DETECTION OF OIL ON THE OCEAN SURFACE

(*b*) U.S. Geological Survey, Menlo Park, California. Contract USDI-USGS-G-560.
(*c*) Dr. John E. Estes, Principal Investigator; Mike Wilson, Project Manager.
(*d*) Experimental, basic, applied.
(*e*) Primary objective is to assess the general utility of Seasat-A L-Band horizontally-polarized synthetic aperture radar (SAR) for detecting oil on the ocean surface. A secondary objective is to determine the transferability of remote sensing methodologies to USGS West Coast Conservation Division for conducting baseline oil pollution studies and fulfilling oil spill detection/monitoring responsibilities. Simulated Seasat data products acquired from an airborne L-Band SAR will, with coincident sea truth data and reconstruction of probable oil slick configurations from meteorological and oceanographic parameters, supplement the existing Seasat SAR data collected over the natural oil seeps in the Santa Barbara Channel before the satellite's failure in October 1978.
(*h*) **Summary Evaluation of the Offshore Target Detection Capabilities of AN/APS-94D and COR Radar Systems,** J. E. Estes, S. P. Kraus, Washington, D.C., U.S. Coast Guard, Contract No. DOT-CG-63898A, 1976.
Airborne Remote Sensing Applications for the Detection and Monitoring of Oil From Natural Seeps and Other Sources, J. E. Estes, S. P. Kraus, Long Beach, Calif., California State Lands Division, 1976.
Oil Seep Survey Over Coal Oil Point and the Santa Barbara Channel, California, October, 1976, S. P. Kraus, J. E. Estes, Long Beach, Calif., California State Lands Division, 1977.
Radar Detection of Surface Oil Slicks, S. P. Kraus, J. E. Estes, S. G. Atwater, J. R. Jensen, and R. R. Vollmers, *Photogrammetric Engineering and Remote Sensing* **43**, 12, pp. 1523-1531, 1977.
AOSS II System Verification Test, S. P. Kraus, J. E. Estes, C. Dennis, P. O'Neill, E. Aderhold, D. Schussle, M. Kronenberg,, Univ. of Calif., Santa Barbara (Under subcontract to Aerojet Electro Systems Co., Azusa, Calif.), 1977.
Comparative Evaluation of Real and Synthetic Aperture Radars for the Detection of Oil and Sea Surface Targets in the Santa Barbara Channel, S. P. Kraus, J. E. Estes, R. R. Vollmers, *Proc. 1977 Oil Spill Conference*, Amer. Petroleum Inst., pp. 203-208, 1977.

023-10841-710-50

GREEN FUEL MOISTURE ESTIMATION USING LANDSAT

(*b*) NASA Headquarters, Office of Space and Terrestrial Applications, Technology Transfer Division, University Applications Program Grant NS6-7220.
(*c*) Susan Atwater, Project Manager.
(*d*) Experimental, applied and basic research for Master's thesis.

(*e*) Landsat data is being studied as an estimator of the moisture content of green fuel, a variable used in the National Fire-Danger Rating system indices for the Los Padres National Forest in California. Green fuel moisture content is defined as the contained moisture in green leaves and twigs of the dense shrub community of chamise chaparral found over much of this forest. Landsat's 4-band multispectral scanner data are combined in different ratios and transformations for input to a regression model to estimate fuel moisture content. The data are corrected for time-lag between sensor and ground data collection and for atmospheric haze. This study encompasses an entire fire season to observe a wide range of moisture conditions.

023-10842-820-50

MULTISPECTRAL MEASUREMENT OF SOIL MOISTURE

(*b*) NASA Goddard Space Flight Center, Greenbelt, Maryland. Atmospheric and Hydrospheric Applications Division. Contract NS6-5170.
(*c*) Susan Atwater, Project Manager.
(*d*) Experimental, basic research.
(*e*) This effort is directed toward the development of linear combination or algorithms employing multispectral sensor data ranging from visible to microwave frequencies that will first use multivariate schemes to classify vegetation and secondly predict soil moisture under any one of several crop types. Experimental data, collected in Guymon, Oklahoma in August 1978, includes: one Seasat SAR overpass; six dates of aircraft-mounted multispectral scanner and scatterometer data; and an extensive set of field data consisting of soil moisture, bulk density, texture and crop cover for 20 agricultural fields.

023-10843-860-33

REMOTE SENSING DETECTION OF PERCHED WATER TABLES: A PILOT STUDY

(*b*) California Water Resources Center, University of California at Davis.
(*c*) Larry Tinney, Project Manager.
(*d*) Experimental, basic, applied.
(*e*) The utility of remote sensing techniques in detecting perched water tables is investigated. Imagery obtained from systems operating within the spectral range 0.4 μm to 23 cm of the electromagnetic spectrum are analyzed.
(*f*) Completed.
(*g*) Results of this study indicate that thermal infrared imagery appears of greatest value in water table detection because of unique soil and water thermal characteristics. Additional studies using thermal inertia modeling techniques in conjunction with aerial thermal infrared imagery will be made. Landsat satellite imagery was shown to be of utility for a regional perspective. Landsat analysis using multidate color composites and ratioing techniques are presently underway.

UNIVERSITY OF CALIFORNIA, SANTA BARBARA, College of Engineering, Department of Mechanical and Environmental Engineering, Santa Barbara, Calif. 93106. Dr. Roy S. Hickman, Department Chairman.

024-10844-070-00

FIXED DOMAIN SOLUTIONS TO FREE SURFACE SEEPAGE PROBLEMS

(*c*) Professor John C. Bruch, Jr., Dept. of Mech. and Env. Engr. and Professor James M. Sloss, Dept. of Mathematics.
(*d*) Theoretical; basic and applied research; Master's and Doctor's theses.
(*e*) Free boundary problems are situations in which one or more of the boundaries is not known a priori. Thus, the location of these free boundaries is an added unknown in the problem which has to be obtained. Such flow situations are being investigated using the Baiocchi method and transformation. This approach yields theoretical results which are rigorous from a mathematical point of view if the problems are formulated as variational inequalities. However, the approach also permits the application of some simple optimization algorithms which compete well with other classical schemes in obtaining numerical results. The numerical scheme ends up being applied to an a priori known, fixed solution domain. The algorithms used are finite difference and finite element successive over-relaxation schemes with projection.
(*h*) **A Variational Inequality Method Applied to Free Surface Seepage from a Triangular Ditch,** J. C. Bruch, Jr., J. M. Sloss, *Water Resources Research* **14**, 1, pp. 119-124, 1978.
Seepage from a Trapezoidal and a Rectangular Channel Using Variational Inequalities, J. C. Bruch, Jr., F. C. Sayle, J. M. Sloss, *J. Hydrology* **36**, pp. 247-260, 1978.
Free-Surface Seepage Problem, J. M. Sloss, J. C. Bruch, Jr., *J. Engineering Mechanics Division, ASCE* **104**, EM5, *Proc. Paper 14058*, pp. 1099-1111, 1978.
A Numerical Solution of an Irrigation Flowfield, J. C. Bruch, Jr., *Intl. J. Numerical and Analytical Methods in Geomechanics* **3**, 1, pp. 23-36, 1979.
An Analysis of Seepage Through a Dam with a Toe Drain, J. C. Bruch, Jr., J. Caffrey, to appear in *The Mathematics of Finite Elements and Applications III*, edited by J. R. Whiteman, Academic Press, 1979.
Seepage Streams Out of Canals and Ditches Overlying Shallow Water Tables, J. C. Bruch, Jr., *J. Hydrology*, 1979 (in press).

CALSPAN ADVANCED TECHNOLOGY CENTER, P.O. Box 400, Buffalo, N.Y. 14225. Orie C. Fritts, President.

025-10845-880-60

ROLE OF REMOTE SENSING IN ASSESSING THE IMPACT OF ACID PRECIPITATION ON AQUATIC AND TERRESTRIAL ECOSYSTEMS

(*b*) Agreement dated 3/22/78, NYSERDA.
(*c*) John R. Schott, Senior Physicist, Environmental Sciences Department.
(*d*) Applied research; laboratory and field.
(*e*) The first of three one-year phases is directed at defining algorithms relating aerial remote sensing parameters to the nature and degree of impact of acid precipitation on aquatic and terrestrial ecosystems. This involves concentrated aerial and ground surveys on a limited number of sites to define the forms environmental impact takes and how these perturbations can be seen and quantified using Calspan's quantitative approach to remote sensing.
(*g*) Strong relationships between optical properties observable by remote sensing and water quality parameters related to acid precipitation effects on lakes have been demonstrated.

025-10846-880-00

EFFECTS OF ACID RAIN ON ADIRONDACK REGION (NEW YORK) SOILS

(*c*) Richard P. Leonard, Head, Environmental Systems Analysis Section.
(*d*) Basic research, laboratory and field.
(*e*) Determine the effects of acid rain on the chemical properties of major Adirondack region soils. In addition, effects of acid rain on soil water chemistry is to be studied. Undisturbed columns of Adirondack soils have been obtained and chemically and physically characterized. Simulated acid rains at different pH's (i.e., pH 2.0; pH 4.0) will be applied to the soils and leachate analyzed for pH, Ca^{++}, Mg^{++}, H^{+}, and K^{+} concentrations. After acid rain leaching for ~ 3-month period, the soil chemical properties will be remeasured and compared to original soil properties. Porous suction cup lysimeters are to be placed in selected

Adirondack soils in the field and chemical properties of soil water measured. Data on soil water chemistry is to be correlated with soil physical and chemical properties, and rainfall chemistry.

CARNEGIE-MELLON UNIVERSITY, Department of Chemical Engineering Schenley Park, Pittsburgh, Pa. 15213.

026-10847-130-00

TRANSPORT RATES OF BROWNIAN PARTICLES IN SOLUTIONS OF MODERATE CONCENTRATIONS

(*c*) Dr. John L. Anderson, Professor of Chemical Engineering.
(*d*) Theoretical; Ph.D. thesis.
(*e*) The net movement of spherical particles by diffusion and sedimentation was examined for solutions in which particle interactions are important. Hydrodynamic and direct interactions at the microscopic level were mathematically analyzed to obtain macroscopic transport coefficients (diffusion and sedimentation coefficients versus particle concentrations).
(*g*) The effect of concentration on particle transport is described by: $D = D_0(1 + k\,\phi)$ and $S = S_0(1 + \alpha\,\phi)$, where D and S are the measurable diffusion and sedimentation coefficients for the particles, ϕ is the particle volume fraction, and the linear coefficients k and α are functions of particle properties (size and density relative to the other particles, viscosity relative to the suspending solvent, and direct potential energy acting between any two particles). Predictive equations for k and α involving definite integrals (which average hydrodynamic interactions among the particles) are given along with sample computations.
(*h*) **Diffusion of Spherical Macromolecules at Finite Concentration,** J. L. Anderson, C. C. Reed, *J. Chem. Phys.* **64,** 3240 (1976); **65,** 4336 (1976).
Diffusion of Interacting Brownian Particles, J. L. Anderson, C. C. Reed, submitted for publication (1979).
Hindered Settling of a Suspension at Low Reynolds Number, C. C. Reed, J. L. Anderson, submitted for publication (1979).

CHICAGO BRIDGE AND IRON COMPANY, Marine Research and Development, Route 59, Plainfield, Ill. 60544. Mr. P. R. Johnson, Director.

027-09013-420-00

WAVE FORCES ON SUBMERGED OBJECTS

(*c*) Dr. S. K. Chakrabarti, Analytical Head.
(*d*) Theoretical and experimental; encompasses both basic and applied research; includes design and developmental works.
(*e*) Development of mathematical model and computer programs to predict the forces on basic components of offshore drilling platforms and storage tanks; data obtained experimentally in a wave tank to validate the theoretical models, determine hydrodynamic coefficients and flow characteristics around submerged objects. Projects include developing potential flow theory for large objects, inertia and drag forces and lift forces on small tubular members in random orientation.
(*h*) **Second-Order Wave Force on Large Vertical Cylinder,** S. K. Chakrabarti, *J. Waterways, Harbors and Coastal Engrg. Div., ASCE* **101,** Aug. 1975.
Wave Forces on Vertical Circular Cylinder, S. K. Chakrabarti, A. L. Wolbert, W. A. Tam, *J. Waterways, Harbors and Coastal Engrg. Div., ASCE* **102,** May 1976.
Total Forces on a Submerged Randomly Oriented Tube Due to Waves, S. K. Chakrabarti, W. A. Tam, A. L. Wolbert, *Proc. Offshore Tech. Conf.*, Houston, Tex., May 1976.
Wave Interaction with a Submerged Open-Bottom Structure, S. K. Chakrabarti, R. A. Naftzger, *Proc. Offshore Tech. Conf.*, Houston, Tex., May 1976.
Transverse Forces on Vertical Cylinders in Waves, (Discussion), S. K. Chakrabarti, *J. Waterways, Harbors and Coastal Eng. Div., ASCE* **102,** Nov. 1976.
Interaction of Water Waves with Cylinder Barrier, (Discussion), S. K. Chakrabarti, *J. Waterways, Port, Coastal and Ocean Div., ASCE* **102,** Feb. 1977.
Cross-Flow Response of Piles Due to Ocean Waves, (Discussion), S. K. Chakrabarti, *J. Engineering Mechanics Div., ASCE* **103,** Apr. 1977.
Forces Due to Nonlinear Waves on Vertical Cylinders, (Discussion), S. K. Chakrabarti, *J. Waterways, Harbors and Coastal Eng. Div., ASCE* **103,** Aug. 1977.
Wave Forces on Inclined Tubes, S. K. Chakrabarti, A. L. Wolbert, W. A. Tam, *Coastal Eng., The Netherlands* **1,** 1977.
Interaction of Waves with a Rigid Submerged Spheroid, (Discussion), S. K. Chakrabarti, R. A. Naftzger, *J. Ship Research* **21,** 3, Sept. 1977.
Nonlinear Wave Forces on Large Offshore Structures, (Discussion), S. K. Chakrabarti, *J. Waterways, Port, Coastal and Ocean Div., ASCE* **103,** Nov. 1977.
Wave Forces on Multiple Vertical Cylinders, S. K. Chakrabarti, *J. Waterway, Port, Coastal and Ocean Division, ASCE* **104,** May 1978, pp. 147-161.
Added Mass of Pile Group, (Discussion), S. K. Chakrabarti, *J. Waterway, Port, Coastal and Ocean Division, ASCE* **104,** May 1978.
Formation and Reversal of Vortices Around Circular Cylinders Subjected to Water Waves, (Discussion), S. K. Chakrabarti, *J. Waterway, Port, Coastal and Ocean Division, ASCE* **104,** May 1978.
Analysis of a Tower-Tanker System, S. K. Chakrabarti, D. C. Cotter, *Proc. 10th Ann. Offshore Technology Conf.*, Houston, Tex. OTC 3202, May 1978, pp. 1301-1310.
Drag and Inertia Forces on a Cylinder in Periodic Flow, (Discussion), S. K. Chakrabarti, *J. Waterway, Port, Coastal and Ocean Division, ASCE* **104,** Aug. 1978.

UNIVERSITY OF CINCINNATI, Department of Chemical and Nuclear Engineering, Cincinnati, Ohio 45221.

028-08670-130-54

TWO-PHASE FLOW PATTERNS

(*b*) National Science Foundation.
(*c*) Dr. Joel Weisman, Professor of Nuclear Engineering.
(*d*) Experimental and theoretical, basic research, theses.
(*e*) Experimental and analytical study of the transitions between flow patterns in vapor-liquid flow.
(*g*) Extensive data have been obtained on the effect of fluid properties, pipe diameter and inclination angle on flow pattern transitions. Dimensionless correlations fitting the present data and those in the literature have been devised for horizontal flow.
(*h*) **Observation and Correlation of Flow Pattern Transitions in Horizontal Cocurrent Gas-Liquid Flow,** W. G. Choe, L. Weinberg, J. Weisman, *Two-Phase Transport and Reactor Safety*, T. N. Veziroglu, S. Kakac, editors, p. 1357 (1978).
Effects of Fluid Properties and Pipe Diameter On Two Phase Flow Patterns in Horizontal Lines, J. Weisman, D. Duncan, J. Gibson, *Intl. J. Multiphase Flow* **5,** (1979).

028-10848-140-82

INVESTIGATION OF TRANSITION BOILING HEAT TRANSFER

(*b*) Electric Power Research Institute.
(*c*) Dr. Joel Weisman, Professor of Nuclear Engineering.
(*d*) Experimental and theoretical.

(*e*) Experimental study of transition boiling of water in vertical tube using hot mercury as a heat source.
(*g*) Data on behavior at low pressures and high void fractions have been obtained in both round tube and an annulus. A reasonable correlating approach has been devised.
(*h*) **Method for Correlation of Transition Boiling Heat Transfer Data,** K. Ramu, J. Weisman, *Proc. 5th Intl. Heat Transfer Conf.* **IV**, 133.0, Tokyo (1974).
Transition Boiling Heat Transfer in a Vertical Annulus, K. Ramu, J. Weisman, *Nuc. Engrg. and Design* **40**, 285 (1970).
Transition Boiling Heat Transfer in a Vertical Round Tube, J. Weisman, Y. K. Kao, G. Rahrooh, *Electric Power Research Inst. Report EPRI NP-895*, (Palo Alto Calif. (1978)).

028-10849-130-54

THE INTERSTITIAL DISTRIBUTION OF LIQUID IN FOAM

(*b*) National Science Foundation.
(*c*) Dr. Robert Lemlich, Professor of Chemical Engineering.
(*d*) Experimental and theoretical, basic research, theses.
(*e*) Study of an isolated Plateau border is combined with study of the electrical conductivity of liquid foam in an effort to determine the interstitial distribution of liquid.
(*g*) Preliminary measurements of the electrical conductivity of polydisperse foam support and extend the classical experimental results of Clark. They also support Lemlich's theoretical limit of 3.0 for the ratio of the volumetric fraction of liquid to the conductivity ratio as the volumetric fraction approaches zero.

028-10850-130-54

A STUDY OF INTERBUBBLE GAS DIFFUSION IN LIQUID FOAM BY MEANS OF A NOVEL TECHNIQUE FOR PREDETERMINING INITIAL BUBBLE SIZE

(*b*) National Science Foundation.
(*c*) Dr. Robert Lemlich, Professor of Chemical Engineering.
(*d*) Primarily experimental, basic research, theses.
(*e*) An experimental study of bubble size measurment and of spontaneous changes in bubble size distribution caused by gas diffusion between bubbles.
(*g*) Recent theory for the effect of interbubble gas diffusion has been further developed, preparatory to experimental testing. Theoretical results show that the progressive changes with time in the various mean radii of the bubbles are sensitive to the initial bubble size distribution. However, the rate of fractional decrease in the total surface area of the bubbles may be much less sensitive.

UNIVERSITY OF CINCINNATI, Department of Civil and Environmental Engineering, Hydraulic Laboratory, Cincinnati, Ohio 45221. Dr. James F. McDonough, Department Head; Dr. H. C. Preul, Directing Head, Hydraulic Laboratory.

029-10082-310-00

FLOOD ROUTING

(*c*) Dr. Louis M. Laushey.
(*d*) Theoretical. Master's thesis.
(*e*) The method proposed solves the continuity and motion equations without solving them simultaneously or without the use of the characteristics curves.
(*g*) A four-point scheme is used to write the finite differences equations, and conditions of stability and convergence are found to be satisfactory for the proposed simpler method of solution.

029-10851-870-00

PROBABILITY ANALYSIS OF COMBINED SEWER OVERFLOWS

(*c*) Dr. Herbert C. Preul.
(*d*) Theoretical; based on data from previous urban runoff project.
(*e*) Work on an approach for analyzing the probability of storm water overflows from a combined sewer system for the purpose of controlling the overflows on a probability basis through detention storage and treatment. Data from 2380 acre urban watershed in Cincinnati, Ohio, U.S.A., are used to illustrate the approach.
(*h*) Paper published in *Proc. 3rd World Congress on Water Resources*, International Water Resources Assoc., Mexico City, Apr. 1979.

029-10852-220-00

RILL FORMATION ON HILLSIDES

(*c*) Dr. Louis M. Laushey.
(*d*) Theoretical and field measurements, Master's thesis.
(*e*) The location down-slope and the spacing of well-developed rills are described by equations and confirmed by field measurements on various newly-cut highway slopes.
(*f*) Suspended.
(*g*) Spacing of rills is found to be surprisingly uniform and predictable, based on soil properties, slope, and rain intensity.
(*h*) To be published by IAHR; meeting in Cagliari, Italy, Sept. 1979.

029-10853-870-00

DEVELOPMENT OF URBAN RUNOFF POLLUTION MODEL

(*c*) Dr. Herbert C. Preul and Master's degree student.
(*d*) Theoretical with computer operations utilizing previously collected field data from an urban runoff project.
(*e*) Project directed at development of a pollution runoff model mainly for urban watersheds.

029-10854-860-36

CARBON FILTRATION

(*b*) Environmental Protection Agency and Cincinnati Water Works.
(*c*) Dr. Louis M. Laushey.
(*d*) Field investigation, Master's thesis.
(*e*) Effectiveness and optimizing of carbon filters, replacing sand filters, are studied in plant-size activated carbon filters at the Cincinnati Water Works.

029-10855-630-70

FLOW TESTING OF VALVES

(*b*) Wm. Powell Co., Cincinnati, Ohio.
(*c*) Dr. Herbert C. Preul.
(*d*) Experimental; applied research.
(*e*) Testing of various types of valves for flow capacities and other characteristics.
(*f*) Completed.

029-10856-800-00

SYSTEMS ANALYSIS

(*c*) Dr. Louis M. Laushey.
(*d*) Theoretical, and research on design methods.
(*e*) One project involves the extension of the Benefit to Cost Ratio to the optimization of a group of water projects. The second involves a critical analysis of the methods available for the optimization of various projects, and suggestions to increase their acceptance and use by practicing engineers.
(*g*) Papers are to be published by IAHR, meeting in Cagliari, Italy, Sept. 1979, and by the World Congress on Water Resources, meeting in Mexico City, Apr. 1979.

029-10857-860-00

UTILIZATION OF WASTE HEAT FOR DESALINATION OF WATER

(*c*) Dr. Herbert C. Preul.
(*d*) Theoretical; Master's thesis.

(*e*) Utilization of waste heat from a gas turbine is being studied for use with desalination of sea waters.

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CLARKSON COLLEGE OF TECHNOLOGY, Department of Civil and Environmental Engineering, Potsdam, N.Y. 13676. Dr. N. L. Ackermann, Department Chairman.

031-09973-300-00

FLOOD PLAIN HYDRODYNAMICS

(*c*) Dr. N. L. Ackermann and Dr. H. T. Shen.
(*d*) Theoretical and experimental; applied research.
(*e*) A two-dimensional mathematical model of a river basin is developed where the interaction effects between the flow in the main channel and overbank portions are included. The model will be used to predict flow conditions in a laboratory flume containing a meandering river reach.
(*f*) Completed.
(*h*) **Mathematical Modeling of River Flood Plains,** K. Avery, *M.E. Thesis*, Clarkson of Technology, Aug. 1977.
Two-Dimensional Flood Plain Modeling, C. D. Smith, *M.E. Thesis*, Clarkson College of Technology, July 1978.
Flood Plain Modeling, N. L. Ackermann, H. T. Shen, presented *ASCE Hydraulics Div. Specialty Conf.*, College Park, Md., Aug. 1978.

031-09974-130-00

MUD FLOWS

(*c*) Dr. N. L. Ackermann and Dr. H. T. Shen.
(*d*) Theoretical and experimental; applied research.
(*e*) The equations of motion are developed for the flow of solid-fluid mixtures such as those which occur during snow avalanches, land slides and mud flows. The constitutive equations are developed using submodels which demonstrate the interactive effects of the solid and fluid portions of the moving mixture. Laboratory scale flow slides are to be produced and analyzed using the theoretical equations developed to the two-component system.
(*h*) **Flow of Granular Material as a Two-Component System,** N. L. Ackermann, H. T. Shen, *Proc. U.S.-Japan Seminar, Continuum Mechanical and Statistical Approaches in the Mechanics of Granular Materials*, sponsored by NSF and JSPS, Sendai, Japan, June 5-9, 1978, pp. 258-265.
Rheological Characteristics of Solid-Liquid Mixtrues, N. L. Ackermann, H. T. Shen, *AIChE. J.*, Mar. 1979.

031-09979-420-00

EFFECTS OF UNIFORM CURRENT ON WAVE FORCES

(*b*) Engineering Foundation.
(*c*) Dr. H. T. Shen.
(*d*) Theoretical; applied research.
(*e*) The effect of uniform current on wave forces is being studied. The force acting on coastal structures when both waves and currents are presented is being calculated. The body surface boundary condition and the free surface boundary condition will be satisfied exactly to the first-order in the infinitesimal-wave approximation. Diffraction theory and integral equation techniques are used in the analysis.

031-09980-020-00

MATHEMATICAL MODELS FOR TRANSIENT MIXING IN NATURAL CHANNELS

(*c*) Dr. H. T. Shen.
(*d*) Applied research.
(*e*) Analytical and numerical models for mixing of nonconservative dispersants in natural channels is being developed. Effects of channel irregularities are considered by using an orthogonal curvilinear (stream-tube) coordinate system.
(*f*) Completed.
(*h*) **Numerical Simulation of Mixing in Natural Rivers,** T. O. Harden, H. T. Shen, *J. Hydraulics Div., ASCE* **105,** HY4, Apr. 1979.
Transient Mixing in River Channels, H. T. Shen, *J. Environmental Engrg. Div., ASCE* **104,** EE2, June 1978.
Line Source Dispersion with Application to Mixing in River Channels, H. T. Shen, *AWAR Paper No. 77069, Water Resources Bulletin* **14,** 1, Feb. 1978.

031-09981-020-00

THE EFFECT OF ICE COVER ON VERTICAL MIXING IN CHANNELS

(*c*) Dr. H. T. Shen.
(*d*) Applied research; M.S. thesis.
(*e*) A two-dimensional numerical solution is used to study the effect of ice cover on vertical mass transfer in channels based on available field data on flow distributions.
(*f*) Completed.
(*h*) **The Effect of Ice Cover on Vertical Transfer in Stream Channels,** H. T. Shen, T. O. Harden, *AWRA paper No. 77118, Water Resources Bulletin*, Dec. 1978.

031-10858-300-15

MECHANICS OF ICE JAM FORMATION IN RIVERS

(*b*) U.S. Army Cold Region's Research and Engineering Laboratory.
(*c*) Dr. N. L. Ackermann, Dr. H. T. Shen.
(*d*) Theoretical and experimental.
(*e*) Theoretical and experimental investigations will be conducted to determine the fundamental mechanics of the formation of ice jams and the relationship of stream characteristics to the formation and breakup of river ice jams.

031-10859-300-15

FLOW AND ICE CONDITIONS IN THE OGDEN ISLAND REACH, ST. LAWRENCE RIVER

(*b*) SLSDC/D.O.T.
(*c*) Dr. N. L. Ackermann, Dr. G. B. Batson, Dr. H. T. Shen.
(*d*) Applied research.
(*e*) Field and theoretical investigations on the hydraulic and ice conditions in the river. Specific studies include the flow distributions in the river, radar airborne remote sensing surveys of ice cover thickness, and the study of hanging dam formations.
(*h*) **Survey of Flow and Ice Conditions in the Ogden Island Reach, St. Lawrence River, Winter of 1977-78,** G. B. Batson, N. L. Ackermann, H. T. Shen, K. I. Candee, *Report No. DOT-SL-78-519*, Wash., D.C., June 1978, 80 pp.
Transverse Flow Distribution in Ice Covered Channels, H. T. Shen, N. L. Ackermann, K. I. Candee, presented *ASCE Hydraulics Div. Specialty Conf.*, College Park, Md., Aug. 1978.

031-10860-870-00

PREDICTIVE MODELS FOR LAKE EUTROPHICATION

(*c*) Dr. J. DePinto, Dr. J. K. Edzwald.
(*d*) Theoretical and field, applied research, M.S. thesis.
(*e*) Develop and test the phosphorus loading model proposed by Vollenwieder and the phosphorus-chlorophyll model of Dillon and Rigler for six lakes of the Northern Adirondack Forest Preserve to assess the utility of the models as tools for managing water quality and productivity in the lakes.
(*f*) Completed.
(*g*) The six lakes had surface areas ranging from 96 to 2820 ha and mean depths ranging from 2.5 to 11.0 m. Areal phosphorus loading rates and retention coefficients were estimated to range from 142 to 472 mg $P\text{-}m^{-2}\text{-}yr^{-1}$, and from 0.52 to 0.85, respectively, among the lakes. Predicted values of phosphorus concentration at spring overturn agreed within 15 percent of measured values for half the lakes, and excepting Star Lake, predictions indicated all lakes were within an oligomesotrophic range of productivity. These predictions agree with most quantitative and qualitative measurements; phosphorus concentrations ranging from 5 to 25 $\mu gP+1^{-1}$ were measured in the lakes,

while chlorophyll-a was not found greater than 5 $\mu g\text{-}l^{-1}$ in any lake. Current efforts are directed toward further analysis of data on the productivity of the lakes, collected during the growing season of 1977, for evaluation of the lake models.

(*h*) **A Phosphorus Budget and Lake Models for Lake Ozonia,** P. M. Cangialosi, *M.S. Thesis*, Clarkson College of Tech., 1976.
A Mathematical Predictive Model for Phosphorus in Lakes, C. Doolittle, *M.S. Thesis*, Clarkson College of Tech., 1976.
An Evaluation of Phosphorus Budgets and Trophic Status Models for Adirondack Lakes, S. C. Martin, *M.S. Thesis, Clarkson College of Tech., 1979.*

031-10861-870-82

ENGINEERING EVALUATION OF POLYMERIC LIGANDS SELECTIVE FOR COPPER (II)

(*b*) International Copper Research Association.
(*c*) Dr. J. DePinto, Dr. J. Edzwald.
(*d*) Experimental and field, applied research, M.S. thesis.
(*e*) Evaluate the feasibility of using synthetic ion exchange resins for the selective removal of copper from mixed metal wastewater produced during brass milling operations.
(*f*) Completed.
(*g*) Five resins were investigated for ion selectivity using brass mill wastewater and a synthetic water containing zinc, nickel, chromium (III), calcium, magnesium iron (II) and copper. Of these metals only iron (II) showed a greater affinity for the resins. However, the rate of exchange of copper was slow, and the exchange capacity of the resins was low (0.06-0.6 meg/g). Copper uptake by the resins, appeared to be limited by internal pore diffusion.
(*h*) **Engineering Evaluation of Polymeric Ligands Selective for Copper (II),** R. A. Niles, *M.S. Thesis, Clarkson College of Tech., 1976.*
The Uptake and Release Properties of Ion Exchange Resins Selective for Copper (II), M. J. Maslyn, *M.S. Thesis, Clarkson College of Tech., 1978.*

031-10862-870-36

KINETIC STUDIES OF DECOMPOSITION AND NUTRIENT REGENERATION OF GREAT LAKES PHYTOPLANKTON

(*b*) U.S. Environmental Protection Agency.
(*c*) Dr. J. DePinto.
(*d*) Experimental, basic research, Ph.D. and M.S. theses.
(*e*) Provide experimental data on the kinetics of decomposition and nutrient regeneration of algal blooms for development of a mechanistic submodel to describe these processes in natural waters, with consideration given to algal species and physiological state, decomposer population, light, and temperature.
(*g*) Data on respiration and phytosynthesis of the green alga, Scenedesmus sp., were collected during axenic, steady-state growth in a light-dark chemostat. Solution of materials balance equations for the system show an endogenous respiration rate of 0.03 day^{-1} at 20 °C for the alga. Current studies seek to quantify the role of mixed bacterial populations in accelerating decompositon of Scenedesmus and other algal species.
(*h*) **Laboratory Study of the Kinetics of Phytoplankton Decomposition and Subsequent Phosphorus Regeneration,** F. J. McKosky, *M.S. Thesis*, Clarkson College of Tech., 1978.

031-10863-860-00

REMOVAL OF HUMIC SUBSTANCES FROM WATER SUPPLIES

(*c*) Dr. J. Edzwald.
(*d*) Experimental, basic research, M.S. thesis.
(*e*) Evaluate the removal of humic substances from water supplies using coagulation and direct filtration processes.
(*g*) Jar tests can be used to predict the polymer dosage required for destabilization of humic particles. Coagulation and filtration are analogous, and over/underdosing of polymer in jar tests predicts dosages which result in over/underdosages of polymer for filtration. Head loss depends on the size of the particles being removed during filtration; thus, a period of flocculation prior to filtration reduces head losses during filtration of destabilized humic particles.
(*h*) **Coagulation and Direct Filtration of Humic Substances with Polyethyleneimine,** H. T. Glaser, *M.S. Thesis*, Clarkson College of Tech., 1979.

031-10864-870-80

ACID PRECIPITATION–RECOVERY OF ACID LAKES

(*b*) Engineering Foundation, Noyes Foundation.
(*c*) Dr. J. Edzwald, Dr. J. DePinto.
(*d*) Experimental, applied research, M.S. thesis.
(*e*) To evaluate the potential value of lime ($Ca(OH)_2$, calcite ($CaCO_3$), and fly ash as materials for reclaiming lakes which have been made acidic due to acid in precipitation. The evaluation is performed in terms of chemical and biological variables which are measured during laboratory experimentation. Particular emphasis is placed on the potential of fly ash treatment as a method of reclamation, since fly ash is a waste product of energy production.
(*g*) The effectiveness of fly ash for neutralizing and buffering acid lake water was variable and depended on the source of the coal which created the ash. Fly ash obtained from coal which was mined in the western U.S. was most effective. Some fly ash samples could neutralize acid lake waters at dosages approximately half those required for the calcium compounds. However, fly ash resulted in lower buffer capacities than lime and calcite, when used alone for treating acid lake water. Further studies of fly ash as a source of heavy metals and its effects on algal growth rates are underway.
(*h*) **Recovery of Adirondack Acid Lakes with Fly Ash Treatment,** R. S. Howell, *M.S. Thesis*, Clarkson College of Tech., 1978.
Continuous-Flow Microcosms for Evaluation of Recovery Techniques for Adirondack Acid Lakes, R. s. Guminiak, *M.S. Thesis*, Clarkson College of Tech., 1979.

031-10865-870-00

EFFECTS OF MANGANESE AND IRON ON ALGAL GROWTH IN AN ADIRONDACK LAKE

(*c*) Dr. J. DePinto, Dr. R. R. Burns.
(*d*) Field, basic research, Ph.D.
(*e*) Determine the effects of iron and manganese on the growth of natural populations of phytoplankton in situ and of Selenastrum capricornutum and Microcystis aeruginosa in axenic continuous culture. Both metals were added in combination with major plant nutrients during field and laboratory investigations.
(*f*) Completed.
(*g*) Iron was moderately stimulatory to blue-green algae in situ at 200 $\mu g/l$, while manganese was inhibitory at 60 to 115 $\mu g/l$ under these conditions and reversed the stimulatory affect of iron. No stimulation of diatoms or green algae was observed in situ. Continuous culture studies showed inhibition of growth of the blue-green algae, M. aeruginose by manganese at concentrations of 115 $\mu g/l$ and higher, while growth of S. capricornutum, a green alga, was only mildly inhibited by 2000 μg Mn/l.
(*h*) **Effects of Manganese and Iron on Algal Growth in an Adirondack Lake,** R. B. Burns, *Ph.D. Dissertation*, Clarkson College of Tech., 1977.

031-10866-870-00

DETERMINATION OF LAKE TROPHIC STATUS BY ALGAL ASSAYS

(*c*) Dr. J. DePinto.
(*d*) Experimental, basic research, M.S. thesis.
(*e*) Assess the trophic status and limiting nutrient relationships in eight lakes of a northern region of the Adirondack Forest Preserve by algal assay procedures in the laboratory and by observation of the succession of phytoplankton in field samples taken from each lake over time.

(*f*) Completed.
(*g*) With the exception of Avalanch Lake, all lakes studied were of low to moderate productivity with phosphorus as the principle nutrient which limited production, nitrogen was less importance to growth limitation. Avalanch Lake would not sustain an assay culture of algae, possibly due to low pH (ca. 4.4). Lake algal communities showed succession from multicellular green algae at spring overturn to diatoms in late spring. Diatoms dominated the phytoplankton community through the summer and gave way to a community of mixed green and blue-green algal species at fall overturn.
(*h*) **Limiting Nutrient and Trophic Level Determination of Lake Ozonia by Algal Assay Procedure,** L. Lepak, *M.S. Thesis*, Clarkson College of Tech., 1976.
Determination of Trophic Status of Lake Ozonia through Algal Monitoring, M. J. Palozzi, *M.S. Thesis*, Clarkson College of Tech., 1978.

031-10869-870-60

ACID PRECIPITATION AND THE SALMON RIVER SYSTEM, TUG HILL, NEW YORK

(*b*) Temporary New York State Commission on Tug Hill.
(*c*) Dr. J. DePinto.
(*d*) Field investigation, basic research, M.S. thesis.
(*e*) Monitor the precipitation in the Salmon River basin and to relate its chemistry to existing acid-rain data in New York State; to evaluate baseline physical and chemical characteristics of the Salmon River which pertain to the acid-rain problem (pH, acidity, alkalinity, $SO_4^{=}$, NO_3^{-}, Ca^{2+}, and total hardness); to record the short-term effects of an acid-rain event on the chemistry of the river; to study the quantity and diversity of the macroinvertebrate community with respect to the water quality of the river.
(*f*) Completed.
(*g*) Precipitation at Tug Hill was at least as acidic as the rest of the northeastern U.S. (mean pH 4.16), and due to the high annual precipitation in the area, total yearly loading of H^+ is higher than the northeastern average. The river system maintains a diverse, productive community of macroinvertebrates and does not show serious effects of acid precipitation. However, data on alkalinity and mineral budgets indicate long-term deterioration may result from continued high-acid inputs. Short-term precipitation events did not affect stream chemistry to the extent of having an adverse effect on the biota, and the most severe environmental conditions occurred during the period of runoff in early spring.
(*h*) **Acid Precipitation and the Salmon River System, Tug Hill, New York,** J. V. DePinto, P. Dentice, *Clarkson College Environmental Engineering Report*, 1977.

CLEMSON UNIVERSITY, Department of Civil Engineering, Clemson Hydraulics Laboratory, Clemson, S.C. 29631. Dr. H. W. Busching, Professor and Head.

032-11651-340-60

A THERMAL DISCHARGE MODEL STUDY OF GRAINGER STEAM STATION

(*b*) S.C. Public Service Authority.
(*c*) B. L. Sill, Assoc. Professor.
(*d*) Experimental, theoretical; applied research.
(*e*) Mathematical and physical hydraulic model study of a thermal discharge into a tidally effected river was conducted as part of an EPA 316a demonstration.
(*f*) Completed.
(*g*) One-dimensional and two-dimensional mathematical models were used to analyze the thermal discharge from Grainger Steam Station. A 1:100 undistorted physical model was also constructed and operated to obtain three-dimensional isotherm distributions. Results from all three techniques compared favorably with field study results. Predictions were made for extreme conditions.
(*h*) *Clemson Hydraulics Laboratory Technical Report No. 77-061.*

032-11652-340-73

DEPLOYMENT AND DISPERSION OF WASTE DISCHARGES FROM OCONEE NUCLEAR STATION

(*b*) Duke Power Company.
(*c*) B. L. Sill, Assoc. Professor.
(*d*) Field study, applied research.
(*e*) Field study to quantify travel times and mixing rates of liquid discharges from Oconee Nuclear Station.
(*f*) Completed.
(*g*) Field surveys of water movement in Lake Hartwell, S.C., involved measurement of bottom topography, drogue surveys, fluorescent dye measurements, and aerial surveillance. Results were used to ascertain travel times and mixing rates of discharges into Lake Hartwell directly below the Lake Keowee Hydroelectric station, with and without hydro operation.
(*h*) *Clemson Hydraulics Laboratory Technical Report No. 78-061.*

032-11653-470-65

PATRIOTS POINT MARINA HYDRAULIC MODEL STUDY

(*b*) Patriots Point Commission (South Carolina).
(*c*) B. L. Sill, Assoc. Professor.
(*d*) Field and experimental; applied research.
(*e*) A field and physical hydraulic model study of Charleston (S.C.) Harbor in the vicinity of Hog Island was conducted to evaluate proposed marina designs.
(*f*) Complete.
(*g*) A physical hydraulic model of a portion of Charleston Harbor was constructed and verified using field study results. Various marina designs were evaluated and a design to minimize shoaling was proposed.
(*h*) *Clemson Hydraulics Laboratory Technical Report No. 79-051.*

032-11654-870-33

FAR FIELD PHYSICAL MODELS OF THERMAL DISCHARGES

(*b*) Office of Water Research and Technology.
(*c*) B. L. Sill, Assoc. Professor.
(*d*) Experimental, theoretical; basic research; Master's thesis.
(*e*) Detailed studies of indoor heat transfer rates from water surfaces are made for use in scaling criteria of far field physical models of thermal discharges. Methods of enhancing transfer rates (and thereby reducing model sizes) are being analyzed.
(*g*) Results for experimental and theoretical indoor surface heat transfer coefficients are complete and agree well. Preliminary surface transfer enhancement tests are complete and a satisfactory scale reduction of a factor of 2 has been obtained.
(*h*) Interim report; *Clemson Hydraulics Laboratory Technical Report No. 79-011.*

COLORADO SCHOOL OF MINES, Basic Engineering Department, Golden, Colo. 80401. Dr. R. R. Faddick.

033-08131-130-70

RHEOLOGY OF MINERAL SLURRIES

(*b*) Commercial.
(*d*) Experimental, basic research, and design.
(*e*) Rheological properties are being measured and pipeline headlosses predicted for coal-alcohol, coal-water, iron concentrates and tailings slurries.
(*g*) Most mineral slurries are yield pseudoplastic.
(*h*) **Pipeline Transportation of Coal-Derived Energy,** R. Faddick, *American Assoc. for the Advancement of Science*, Houston, Tex., Jan. 5, 1979.

033-10281-260-47

EXPERIMENTAL VERIFICATION OF A PNEUMATIC TRANSPORTATION SYSTEM FOR THE RAPID EXCAVATION OF TUNNELS

(*b*) U.S. Department of Transportation.
(*d*) Experimental, basic research, and design.
(*e*) Operating cost and equipment wear were evaluated for a pneumatic pipeline system 600 ft long, 10 inches in diameter transporting 100 tons/hr of stones and gravel. A 16 mm sound-color movie is available.
(*f*) Completed.
(*g*) Operating costs and equipment wear are high.
(*h*) *Report No. UMTA-MA-06-0025-78-14*, Dec. 1978, Final Report (same title) available from NTIS.

033-10870-870-36

THE ENVIRONMENTAL AND POLLUTION ASPECTS OF COAL SLURRY PIPELINES

(*b*) U.S. Environmental Protection Agency.
(*d*) Field and literature investigation.
(*e*) Environmental impacts of coal slurry pipelines studied during design, construction, and operation stages.
(*f*) Completed.
(*g*) Environmental and pollution aspects of coal slurry pipelines as a system are less than alternative transportation modes.
(*h*) **The Environmental and Pollution Aspects of Coal Slurry Pipelines,** R. Faddick, *Report to EPA*, Contract No. EPA R 804616-01-0, Cincinnati, Ohio, Apr. 1978.

033-11546-260-52

EXPERIMENTAL DESIGN FOR HYDRAULIC TRANSPORT

(*b*) U.S. Department of Energy.
(*d*) Field and literature investigation.
(*e*) Contractor team assembled to schedule testing program for coarse coal hydrotransport research facility.

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UNIVERSITY OF COLORADO AT BOULDER, College of Engineering and Applied Science, Department of Civil, Environmental and Architectural Engineering, Boulder, Colo. 80309. Dr. George G. Goble, Department Chairman.

034-10871-860-33

URBAN WATER CONSERVATION

(*b*) Office of Water Research and Technology, Denver Water Department and Engineering Foundation.
(*c*) Dr. J. Ernest Flack.
(*d*) Applied research, M.S. thesis and reports.
(*e*) Study of methods of achieving urban water conservation including structural, operational, economic and socio-political procedures.
(*f*) Partially completed.
(*g*) Handbook available.
(*h*) **Achieving Urban Water Conservation,** *Completion Report*, Water Resources Research Inst., Colo. State Univ., Fort Collins, Colo. 80523, $6.00.

034-10872-360-00

A STUDY OF THE CHARACTERISTICS OF THE HYDRAULIC JUMP OVER A ROUGH-POROUS BED

(*c*) Dr. J. Ernest Flack or Dr. William C. Hughes.
(*d*) Basic research, preliminary work in form of M.S. thesis.
(*e*) A study of the characteristic parameters used to defne the hydraulic jump when the jump forms over a very rough and porous bed composed of rock-bound gabions with reverse underflow.
(*f*) Suspended.
(*g*) Preliminary work completed.

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COLUMBIA UNIVERSITY, Department of Civil Engineering and Engineering Mechanics, New York, N.Y. 10027. Professor M. P. Bieniek, Chairman.

035-11629-240-00

FINITE ELEMENT ANALYSIS OF TRANSIENT PROBLEMS IN FLUID DYNAMICS

(*c*) Professor M. P. Bienick.
(*d*) Theoretical; applied research.
(*e*) The study consists of development of variational principles for non-steady state motion of compressible viscous fluids, formulation of a finite-element discretization scheme, and an upwind weighting method to assure stability of the solution. Applications are directed towards problems of aeroelastic and hydroelastic interactions.
(*g*) A stable numerical method for one- and two-dimensional problems has been obtained.
(*h*) **Finite Element Method in Transient Aeroelastic Problems,** H. C. Clark, *Dissertation*, Columbia University, 1978.

035-11630-240-00

DYNAMIC RESPONSE OF SUBMERGED STRUCTURES

(*d*) Theoretical; applied research.
(*e*) The Inertial Damping Collocation Approximation (IDCA) for fluids is being applied to the steady state and transient response of submerged spherical shells. The results obtained are being compared with earlier proposals for uncoupling equations of motion of the fluid from those of the shell.

035-11631-240-00

DYNAMIC RESPONSE OF FLUID-FILLED SHELLS

(*c*) Professor Frank DiMaggio.
(*d*) Theoretical; applied research.
(*e*) The dynamic analysis of the wall of a fluid-filled unstiffened nuclear containment vessel, to the fluid pressure exerted on it when the relief value discharge piping is cleared, is extended into the plastic range.
(*f*) Completed.
(*h*) **Dynamic Elastic-Plastic Response of Containment Vessel to Fluid Pressure Pulses,** G. Nikolakopoulou, F. DiMaggio, *Computers and Structures* **10**, pp. 659-667, 1979.

035-11632-640-54

WIND STRUCTURE INTERACTION WITH EMPHASIS ON STOCHASTIC METHODS

(*b*) National Science Foundation.
(*c*) Professor M. Shinozuka and R. Vaicaitis.
(*d*) Theoretical; applied research.
(*e*) Mathematical modeling and statistical description of wind flow-induced motions of bluff structures for a variety of flow characteristics. Identification of wind-structure interaction systems by analyzing wind input and structural response in time domain. Response of structures in ocean environment. Study of instantaneous local wind pressures and their extreme value statistics by non-Gaussian stochastic modeling and simulation.
(*h*) **Parametric Study of Wind Loading on Structures,** R. Vaicaitis, M. Shinozuka, M. Takeno, *Proc. ASCE*, **99**, ST3, Mar. 1973.
Response Analysis of Tall Buildings to Wind Loading, R. Vaicaitis, M. Shinozuka, M. Takeno, *Proc. ASCE* **101**, ST3, Mar. 1975.
Cross-Flow Response of Piles Due to Ocean Waves, R. Vaicaitis, *J. Engrg. Mechanics Division, ASCE* **102**, EM1, Feb. 1976.
Dynamic Analysis of Fixed Offshore Structures Subject to Wind Generated Waves, M. Shinozuka, C. Yun, R. Vaicaitis, *J. Structural Mechanics*, 5(2), pp. 135-146, 1977.

035-11633-420-21

PREDICTION OF SEVERE WAVES FOR THE SAFETY AND DESIGN OF A MARINE VEHICLE

(*b*) David W. Taylor Naval Ship Research and Development Center.
(*c*) Professor M. Shinozuka.
(*d*) Theoretical; basic research.
(*e*) Develop a method by which the spectral density of the encounter wave for a linear vehicular movement can analytically be obtained even under the condition of a short-crested sea and the encounter wave elevation can be generated as a sample function of a one-dimensional random process of time. The present investigation also indicates that the proposed method can predict and generate the moment due to a transverse wave effect to be considered for the evaluation of the roll motion of the vehicle as it proceeds linearly in a short-crested sea.
(*f*) Completion as of June 30, 1979.
(*g*) The encounter wave spectrum in a short-crested sea is derived and used in a numerical procedure to generate time histories of sea surface elevation and righting moment which a vehicle experiences as it moves.
(*h*) **Prediction of Severe Waves for the Safety and Design of a Marine Vehicle,** M. Shinozuka, *Columbia Univ. Tech. Rept. No. N00167-79-M-0863*, June 1979.

035-11634-130-40

ANALYSIS OF THE MOTION OF A TANK-TREADING FLIPPING ELLIPSOIDAL PARTICLE IN A SHEAR FLOW

(*b*) Sponsored in part by the National Institutes of Health.
(*d*) Theoretical; basic research.
(*e*) In order to better understand the behavior of suspensions of deformable particles such as certain polymer solutions and blood, a simplified physical model for the motion of a single particle is investigated.
(*g*) Preliminary results have indicated four admissible classes of motion for a single particle with the type of motion determinable from a knowledge of certain kinematic and geometric parameters.

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COLUMBIA UNIVERSITY, Lamont-Doherty Geological Observatory (see Lamont-Doherty Geological Observatory listing).

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UNIVERSITY OF CONNECTICUT, Marine Sciences Institute, Groton, Conn. 06340. S. Y. Feng, Institute Director.

036-11636-220-22

AN INVESTIGATION OF THE IMPACT OF THAMES RIVER DREDGING AND ASSOCIATED SPOILS DISPOSAL OPERATIONS ON LOCAL SUSPENDED MATERIAL TRANSPORT

(*b*) U.S. Navy.
(*c*) Dr. W. F. Bohlen.
(*d*) Field investigations; applied research.
(*e*) Detailed field surveys have been conducted to evaluate the dispersion of sediments introduced into the water column during estuarine dredging operations. These data have been used within a numerical modeling scheme sufficient to provide predictions of the spatial distributions of dredge resuspended sediments under a variety of flow conditions.
(*f*) Completed.
(*h*) **Suspended Material Distributions in the Wake of Estuarine Channel Dredging Operations,** W. F. Bohlen, D. F. Cundy, J. M. Tramontano, *Estuarine and Costal Marine Sciences* (in press), 1978.
Factors Governing the Concentration and Distribution of Suspended Sediments Introduced by Dredging Operations in Estuaries, W. F. Bohlen, *Proc. 16th Coastal Engrg. Conf.*, Hamburg, Germany (in press), 1978.
A Numerical Simulation of the Dispersion of Sediments Suspended by Estuarine Dredging Operations, D. F. Cundy, W. F. Bohlen, *Proc. Workshop Wetland and Estuarine Processes and Water Quality Modeling*, New Orleans, La., June, 1979. U.S. Army Corps of Engineers (in press), 1979.

036-11637-220-22

FIELD INVESTIGATIONS OF SEDIMENT TRANSPORT IN THE VICINITY OF SELECTED COASTAL DREDGE DISPOSAL AREAS: LONG ISLAND SOUND TO THE GULF OF MAINE

(*b*) U.S. Navy.
(*c*) Dr. W. F. Bohlen.
(*d*) Field investigations; applied research.
(*e*) Investigation is designed to evaluate the extent of sediment transport induced by aperiodic storm events. Particular emphasis is placed on selected coastal areas presently used as disposal sites for dredged materials. Storm effects are to be evaluated using an *in situ* instrumentation array containing optical sensors, a current meter, and a pumped filtration system for direct sampling of suspended material composition and concentration.

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UNIVERSITY OF CONNECTICUT, School of Engineering, Storrs, Conn. 06268. Professor C. J. Posey. (Summer address: Rocky Mountain Hydraulic Laboratory, Allenspark, Colo. 80510.)

037-05489-370-61

BOUND-ROCK EROSION PROTECTION FOR HIGHWAY DRAINAGE DITCHES

(*b*) Inst. of Water Resources; State Highway Department.
(*d*) Experimental; applied.
(*e*) Develop application of scientific erosion-protection method to highway ditches. Experiments will provide necessary design data and develop construction methods for low-cost installations.
(*f*) Trial installation on Route I-91 under continuing observation; others being planned.
(*g*) Trial installation on Route I-91 performing satisfactorily; standard specifications being prepared.
(*h*) **High Speed Ground Transportation Brings New Drainage Problems,** C. J. Posey, *High Speed Ground Transportation J.* **8,** 1, pp. 165-175.

037-05769-220-61

FILTER EROSION PROTECTION

(*b*) Water Resources Institute.
(*d*) Basic research; experimental.
(*e*) To determine whether finest-grained non-cohesive and/or cohesive materials can be protected by Terzaghi-Vicksburg inverted filter.
(*g*) If undermining of erosion protection by leaching out of material from underneath is to be avoided, the layers must meet the Terzaghi-Vicksburg inverted filter specifications. Rapidity of failure is proportional to degree of departure from the specifications. Filter layer that will protect $D_{50} =$ 0.045 mm will protect any finer non-soluble material.
(*h*) **Erosion Control:Stability of Rock Sausages,** C. J. Posey, *Univ. of Conn. Inst. of Water Resources Rept. 19*, Nov. 1973, 15 pages.
Erosion-Proofing Drainage Channels, C. J. Posey, *J. Soil and Water Conservation* **28,** 2, 1973, pp. 93-95.

037-09009-220-00

TESTS OF SCOUR PROTECTION FOR BRIDGE PIERS

(*b*) Basic experimental.
(*e*) To see if reverse filter layers placed around bridge piers could prevent localized scour of non-cohesive bed material. Round and diamond-shaped piers were tested in a flume two meters wide, using simulated floods.

(*f*) Completed.
(*g*) To explore the method of limiting the depth of scour by surrounding the pier with protective material, model tests were made covering a range of constriction percentages, depths of flow, and Froude numbers, using both round and elongated piers. After determining the extent of the scour hole formed during the passage of a simulated flood, the protection afforded by a layer of protective material was tested with a repetition of the same flood. If the layer was large enough to resist being moved and had a grain-size distribution capable of preventing leaching, no scour hole formed. A special test showed protection remaining intact despite stream bed degradation.
(*h*) **Tests of Scour Protection for Bridge Piers,** C. J. Posey, *J. Hydraulics Division, ASCE* **100,** HY12, *Proc. Paper 11017*, Dec. 1974, pp. 1773-1783.

037-09010-220-00

ECONOMICAL EROSION PROOFING OF SUPERCRITICAL FLOW SECTIONS

(*c*) Dennis Morrow, Engrg. Research Center, A-318, Fort Collins, Colo. 80523.
(*d*) Applied experimental research. Master's thesis.
(*e*) Develop economical drop structure using rock sausages.
(*f*) Completed.
(*g*) By use of inverted filter base, crest with side constrictions, and sufficiently long rock sausages, structure can have trapezoidal section throughout. Possible ranges of height of drop and length of sausage, as determined by the model tests, are given in the thesis.

037-09011-450-00

MATHEMATICAL MODEL OF TIDAL MOTION IN LONG ISLAND SOUND

(*b*) University of Connecticut Research Foundation.
(*c*) Dr. J. D. Lin, Civil Engineering Department.
(*d*) Analytical and computational; basic research for Master's and Doctoral theses.
(*e*) Mathematical models both in one and two spatial dimensions are constructed for numerical experimentations of tide-related dynamical motions in Long Island Sound. The two-dimensional model may also be used to study unsteady, forced motion in a subregion in the Sound.
(*f*) Completed.
(*g*) Previous studies of tidal motion in Long Island Sound are reviewed. The one-dimensional tidal computational model represents a significant refinement and yields useful information on the bottom friction. The two-dimensional tidal model has been tested for stability and convergence of the computational schemes. Two simulation studies, Hurricane Agnes of 1972 and the Great New England Hurricane of 1938, indicate that the model provides excellent results for severe storms.
(*h*) **Tidal Motion in Long Island Sound,** J. Skridulis, *Ph.D. Thesis*, Univ. of Connecticut, 1979.
Tidal Motion in Long Island Sound, I. One-Dimensional Tidal Computation, J. D. Lin, J. Skridulis, submitted for publication.
Tidal Motion in Long Island Sound, II. Tidal Computational Model and Applications, J. Skridulis, J. D. Lin, submitted for publication.

037-09012-870-61

SPREADING OF OIL SLICKS IN A WIND-WAVE CHANNEL

(*b*) Water Resources Institute.
(*c*) Dr. J. D. Lin, Civil Engineering Department; Dr. G. S. Campbell, Mechanical Engineering Department.
(*d*) Experimental, basic research for M.S. and Ph.D. theses.
(*e*) Experimental study of oil spreading in a laboratory wind-wave channel to determine the effect of wind and waves on the convection and dispersion of oil films on the surface of water.
(*f*) Completed.
(*h*) **Drift Velocities of Surface Films Over Waves,** M. C. Mohr, *M.S. Thesis*, Univ. Connecticut, 1977.
Drift Velocity of Surface Films Over Waves, J. D. Lin, M. C. Mohr, G. S. Campbell, *Proc. 17th Congress of IAHR*, pp. 173-179, 1977.

CORNELL UNIVERSITY, Department of Environmental Engineering, School of Civil and Environmental Engineering, Ithaca, N.Y. 14853. Daniel P. Loucks, Department Chairman.

038-09940-440-54

FINITE ELEMENT ANALYSIS TO THE POLLUTION ANALYSIS OF LAKES

(*b*) National Science Foundation.
(*c*) Dr. James A. Liggett and Dr. J. R. Salmon.
(*d*) Basic theoretical research.
(*e*) Development of finite element models to compute lake circulation and the dispersion of pollutant in lakes. Also development of the computer graphics software to generate input data and display results.
(*h*) **A Graphical Computation System for Three-Dimensional Lake Circulation and Contaminant Dispersion,** J. A. Liggett, R. H. Gallagher, J. R Salmon, G. Blandford, *Proc. Hydraulic Div. Specialty Conf., ASCE*, Aug. 1978.

038-09941-440-44

COASTAL CURRENTS AND SEDIMENT TRANSPORT ON GREAT LAKES SHORELINE

(*b*) NOAA, Sea Grant Program, U.S. Dept. of Commerce.
(*c*) Philip L-F. Liu.
(*d*) Applied research.
(*e*) Examine and modify the existing models for calculating the coastal currents and sediment transports and to develop a complete and flexible model of a system which is suitable for predicting the coastal currents and sedimentary patterns in the New York Great Lakes coastal zone; investigate the water movement in harbors along the Great Lakes shoreline and to study the effectiveness of different types of breakwaters as protective measures for harbor improvements.
(*h*) **Finite Element Modeling of Nearshore Circulation,** P. L-F. Liu, G. Lennon, *Intl. Conf. Applied Numerical Modeling*, Southampton, England, July 11-15, 1977.
Bottom Frictional Stresses and Longshore Currents Due to Waves with Large Angles of Incidence, R. A. Dalrymple, P. L-F. Liu, *J. Marine Research* **26,** 2, 1978.
Waves Over Soft Muds: A Two Layer Fluid Model, P. L-F. Liu, R. A. Dalrymple, *J. Phys. Oceanography* **8,** 6, 1978.
Combined Wave Refraction and Diffraction, P. L-F. Liu, C. J. Lozano, *ASCE Specialty Conf. Coastal Structure* **79,** Mar. 14-16, 1979.

038-09943-440-80

TURBULENCE MEASUREMENTS IN A LAKE

(*b*) The Engineering Foundation.
(*c*) James A. Liggett and Peter J. Murphy.
(*d*) Basic experimental research.
(*e*) Measurement of eddy diffusivity in a stratified lake.
(*f*) Completed.
(*h*) **Turbulence Measurements in a Lake,** B. Brumley, P. J. Murphy, *5th Biennial Symp. on Turbulence in Liquids*, Rolla, Mo., 1977.

038-09945-070-54

BOUNDARY INTEGRAL SOLUTIONS TO GROUNDWATER PROBLEMS

(*b*) National Science Foundation.
(*c*) James A. Liggett and Philip L-F. Liu.
(*d*) Basic theoretical research.
(*e*) Development of boundary integral techniques for the solution of a variety of problems in flow in porous media in two and three dimensions. Also development of the com-

puter graphics software to generate input data and display results.

(*h*) **An Efficient Numerical Method of Two-Dimensional Steady Groundwater Problems,** P. L-F. Liu, J. A. Liggett, *Water Resources Research* **14,** 3, June 1978.

Boundary Solutions to Two Problems in Porous Media, P. L-F. Liu, J. A. Liggett, *J. Hydraulics Div., ASCE*, Mar. 1979.

038-10873-420-54

NUMERICAL MODELING OF TSUNAMIS

(*b*) National Science Foundation.
(*c*) Dr. P. L-F. Liu and Dr. J. A. Ligget.
(*d*) Basic theoretical research.
(*e*) The Boundary Integral Equation Method is being used to calculate the generation, transmission, and shoreline effects of earthquake produced waves.

038-10874-860-33

EVALUATION OF STOCHASTIC STREAMFLOW MODELS FOR THE DETERMINATION OF MUNICPAL RESERVOIR RELIABILITY

(*b*) Office of Water Research and Technology, U.S. Department of the Interior.
(*c*) Dr. J. R. Stedinger.
(*d*) Applied research.
(*e*) The study is investigating the sensitivity of simulated multireservoir system behavior to the choice of streamflow generating models, using New York City's reservoirs in the upper Delaware River as an example. Attention has been paid to techniques used to fit marginal distributions in each month.
(*h*) **Fitting Lognormal Distributions and the Moments Criteria,** J. R. Stedinger, submitted to *Water Resources Research*, 1979.

Lambda and Wakeby Distributions: Parameter Estimation and a Comparison of Flexibility, J. R. Stedinger, A.N.F.G. Henriques, submitted to *Comm. of the ACM*, 1979.

038-10875-860-54

INTERACTIVE WATER RESOURCES PLANNING USING COMPUTER GRAPHICS

(*b*) National Science Foundation.
(*c*) Dr. D. P. Loucks.
(*d*) Applied research.
(*e*) Use of interactive computer graphics as a means of inputting data and displaying results of multipurpose, multiobjective water resources optimization and simulation models and of providing planners and decisionmakers with the capability of interacting with such models in their search for acceptable solutions to planning problems.
(*h*) **Water Resources Planning Using Computer Graphics,** P. N. French, L. E. Johnson, D. P. Loucks, D. P. Greenberg, *Preprint 3342, ASCE Chicago Meeting*, Oct. 1978. User's Manual available, contact D. P. Loucks.

038-10876-860-33

MULTI-PARAMETER WATER QUALITY MANAGEMENT MODELS

(*b*) Office of Water Research and Technology, U.S. Department of the Interior, and National Science Foundation.
(*c*) Dr. D. P. Loucks.
(*d*) Applied research.
(*e*) Adaptation of existing multiparameter aquatic water quality simulation models for use in optimization models designed to evaluate alternative management plans and costs.

038-10877-820-56

THE DESCRIPTION OF LAND SUBSIDENCE BY MEANS OF A VISCOELASTIC AQUIFER MODEL

(*b*) U.S. AID (Fellowship).
(*c*) Dr. W. H. Brutsaert.
(*d*) Theoretical and computational.
(*e*) The sinking or settling of the land surface resulting from groundwater withdrawal is a serious problem which is encountered in many places in the world. Better methods are needed to describe this phenomenon and to predict its magnitude.
(*f*) Completed.
(*g*) A solution was obtained for the problem of compaction of a groundwater pressure in a confined viscoelastic aquifer. This solution was applied to a major confined aquifer system in the San Joaquin Valley in California.
(*h*) **Pumping of Aquifer With Viscoelastic Properties,** W. Brutsaert, M. Y. Corapcioglu, *J. Hydraulics Division, ASCE* **102,** HY11, 1663-1675, Nov. 1976.

Viscoelastic Aquifer Model Applied to Subsidence Due to Pumping, M. Y. Corapcioglu, W. Brutsaert, *Water Resources Research* **13,** 3, 597-604, 1977.

Comparison of Solutions for Delayed-Yield Aquifers, W. Brutsaert, M. Y. Corapcioglu, *J. Hydraulics Division, ASCE* **104,** HY8, 1188-1191, 1978.

038-10878-810-54

THE DETERMINATION OF REGIONAL EVAPOTRANSPIRATION BY MEANS OF STANDARD METEOROLOGICAL DATA

(*b*) National Science Foundation, and Office of Water Research and Technology, U.S. Department of the Interior.
(*c*) Dr. W. H. Brutsaert.
(*d*) Theoretical and analysis of experimental data.
(*e*) A method was developed to the point where it can now be applied to calculate areal evapotranspiration from a region even when the water supply to the surface may be limited. The method requires only regularly observed upper-air ("rawinsonde") meteorological data, and it is based on the similarity parameterization of the atmospheric boundary layer.
(*f*) Completed.
(*g*) The main result is the determination of the water vapor profile function, which was previously unknown. This makes the method a reliable tool in practical applications in hydrology and water resources studies.
(*h*) **Determination of Regional Evapotranspiration From Upper Air Meteorological Data,** J. A. Mawdsley, W. H. Brutsaert, *Water Resources Research* **13**, 539-548, 1977.

Similarity Functions D for Water Vapor in the Unstable Atmospheric Boundary Layer, W. H Brutsaert, F. K. F. Chan, *Boundary Layer Meteorology*, Aug. 1978.

038-10879-300-00

BASEFLOW AND NATURAL AQUIFER DRAINAGE DURING DROUGHTS IN THE FINGER LAKES REGION

(*c*) Dr. W. H. Brutsaert.
(*d*) Theoretical, and analysis of streamflow data.
(*e*) It is important to know and to be able to predict the rate of flow that a given watershed can sustain in the absence of precipitation and in the absence of artificial storage works. The project was concerned with the similarity of the drought flows from a number of rivers with a geomorphologically homogeneous region.
(*f*) Completed.
(*g*) Several theoretical models available in the scientific literature were tested with published streamflow data. It was found that it is possible to determine the base flow at any location within the region on the basis of geomorphological parameters, namely, drainage area and total stream length.
(*h*) **Regionalized Drought Flow Hydrographs from a Mature Glaciated Plateau,** W. H. Brutsaert, J. L. Nieber, *Water Resources Research* **13,** 3, 637-643, 1977.

038-10880-820-33

ESTIMATING RECHARGE TO THE GROUNDWATER RESERVOIR IN SUFFOLK COUNTY, NEW YORK BY MEASURING SOIL-WATER FLOW

(*b*) Office of Water Research and Technology, U.S. Department of the Interior.
(*c*) Dr. T. S. Steenhuis and Dr. W. H. Brutsaert.
(*d*) Experimental and computational.
(*e*) To compare and evaluate different methods of predicting groundwater recharge, and to apply these to the problem of regional estimation.
(*g*) An experimental site is being instrumented to measure soil-water parameters from which the downward flow can be calculated. In addition, micrometeorological measurements allow the determination of regional evaporative losses.

038-10881-590-52

OCEAN THERMAL ENERGY CONVERSION AND PERTURBATIONS IN THE AMBIENT STRATIFIED OCEAN

(*b*) Division of Solar Energy, U.S. Department of Energy.
(*c*) Dr. G. H. Jirka.
(*d*) Theoretical and laboratory experimentation.
(*e*) Ocean Thermal Energy conversion (OTEC) plants are proposed to utilize the thermal energy difference which exists in the stratified tropical ocean to produce electrical power. Because of their low thermal efficiencies very large flow rates are required. The project is concerned with the analysis of the perturbations in the form of internal density currents which are produced by the continuous discharge of these high flow rates.
(*g*) The formation of a density current from a stationary OTEC plant in a flowing stratified ocean has been considered. The governing equations for either discretely or linearly stratified ocean conditions have been developed and exhibit the formation of critical lines and shock fronts. Solution methods similar to those used in compressible gas dynamics are being utilized.
(*h*) **Evaluation of Mixing and Recirculation in Generic OTEC Discharge Designs,** D. J. Fry, G. H. Jirka, E. E. Adams, *Proc. 5th Ocean Thermal Energy Conversion Conf.*, Miami, Fla., Jan. 1978.
Selective Withdrawal from Two-Layered Fluid Systems: Part 1: Two-Dimensional Skimmer Well, G. H. Jirka, *J. Hydraulic Research* (in press), 1979.
Selective Withdrawal from Two-Layered Fluid Systems: Part 2: Three-Dimensional Round Intake, G. H. Jirka, D. S. Katavola, *J. Hydraulic Research* (in press), 1979.

038-10882-050-00

MIXING OF BUOYANT PLUMES IN CROSSFLOW

(*c*) Dr. G. H. Jirka.
(*d*) Theoretical and experimental.
(*e*) The mixing characteristics of buoyant plumes, such as generated from sewage discharges in the coastal zone and in the presence of a coastal current, are being examined. Particular phenomena under consideration are the generation of internal plume vortices, plume bifurcation and buoyant spreading at the free surface and the effect of initial jet swirling.
(*h*) **Stability and Mixing of Vertical Plane Buoyant Jet in Confined Depth,** G. H. Jirka, D. R. F. Harleman, *J. Fluid Mechanics* (in press), 1979.

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CORNELL UNIVERSITY, Sibley School of Mechanical and Aerospace Engineering, Ithaca, N.Y. 14853. Professor A. R. George, Director.

039-10996-020-54

EXPERIMENTS IN TURBULENCE AND MICROMETEOROLOGY

(*b*) National Science Foundation, Meteorology and Fluid Dynamics Program.
(*c*) Z. Warhaft, Asst. Professor of Engineering.
(*d*) Basic, experimental, thesis.
(*e*) Experiments pertaining to the mixing of scalars such as temperature and moisture in turbulent flows with and without the effects of buoyancy.
(*g*) See (e) and (h).
(*h*) **An Experimental Study of the Decay of Temperature Fluctuations in Grid Generated Turbulence,** Z. Warhaft, J. L. Lumley, *J. Fluid Mech.* **88,** 4, pp. 659-684 (1978).
The Decay of Temperature Fluctuations and Heat Flux in Grid Generated Turbulence, Z. Warhaft, J. L. Lumley, *Lecture Notes in Physics* **76,** Springer Verlag, Berlin, (1978).
Simultaneous Measurements of Turbulence in the Lower Atmosphere Using Sonar and Aircraft, D. W. Thomson, R. L. Coulter, Z. Warhaft, *J. Applied Meteorology* **17,** 6, June 1978.

039-10997-450-54

DYNAMICS OF THE OCEAN MIXED LAYER AND LANGMUIR CIRCULATIONS

(*b*) National Science Foundation.
(*c*) Sidney Leibovich, Professor of Mechanical & Aerospace Engineering.
(*d*) Basic, theoretical research.
(*e*) The role played by Langmuir circulations in providing a wind-induced stirring of the mixed layer in oceans and lakes has been and continues to be, investigated. This has been carried out by constructing a theory in which interactions between the surface wave field and the wind forced current are of primary interst. The theory provides cellular motion in good accord with field observations by two mechanisms. One mechanism leads to a direct forcing of convective motions: the other leads to convective activity due to an instability mechanism. Heat transfer by the convective motions is of interest, as well as momentum transfer and current development.
(*g*) See (h) for work already reported. Present activity includes investigation of the stability characteristics, both to infinitesimal disturbances and to distrubances of arbitrary magnitude. Direct finite difference simulations of the time development of the fully nonlinear instability model of the ocean mixed layer and thermocline as a result of Langmuir circulation activity have also been carried out.
(*h*) **A Rational Model for Langmuir Circulations,** A. D. D. Craik, S. Leibovich, *J. Fluid Mech.* **73,** pp. 401-426 (1976).
On the Evolution of the Wind-Drift/Langmuir Current System in the Ocean. Part I: Theory and the Averaged Current, S. Leibovich, *J. Fluid Mech.* **79,** pp. 715-744 (1977).
On the Evolution of the Wind-Drift/Langmuir Current System in the Ocean. Part II: Numerical Solutions for the Langmuir Cells, S. Leibovich, K. Radhakrishnan, *J. Fluid Mech.* **80,** pp. 481-508 (1977).
Convective Instability in Stably Stratified Water, S. Leibovich, *J. Fluid Mech.* **82,** pp. 561-581 (1977).

039-10998-020-54

TURBULENCE MODELING

(*b*) National Science Foundation, Meteorology Program; Office of Naval Research, Fluid Dynamics Branch.
(*c*) John L. Lumley, Willis H. Carrier, Professor of Engineering.
(*d*) Basic; theoretical; thesis.

(*e*) Modeling of turbulence, particularly mixing and reaction of two scalars; hydraulic applications include heat/salt transport in the ocean, thermocline erosion, phytoplankton/zooplankton balance, pollution transport in estuaries.
(*g*) Successful incorporation of buoyancy in turbulent transport; incorporation of salt fingering in two-scalar model; method of approach to slow nonexothermic reactions; beginnings of intermittency model at density interface.
(*h*) **Turbulent Transport of Passive Contaminants and Particles: Fundamentals and Advanced Methods of Numerical Modeling,** J. L. Lumley, *Lecture Series 1978-7 Pollutant Dispersal*, Von Karman Institute for Fluid Dynamics, Rhode-St-Genese, Belgium, (1978).
Computational Modeling of Turbulent Flows, J. L. Lumley, *Advances in Applied Mechanics* **18,** C.-S. Yih, ed., Academic Press, N.Y., pp. 124-176 (1978).
Second Order Modeling of Turbulent Flows, J. L. Lumley, *Lecture Series 1979-1 Prediction Methods for Turbulent Flows*, Von Karman Institute for Fluid Dynamics, Rhode-St-Genese, Belgium, (1979).
A New Kind of Realizability in Turbulent Modeling of the Planetary Boundary Layer, J. L. Lumley, *Proc., NOAA/AFOSR Workshop The Planetary Boundary Layer*, Boulder, Colo., Aug. 1978 (1979).
Some Fundamental Aspects of Turbulence with Implications in Geophysical Flows, J. L. Lumley, *Proc. 11th Intl.-Liege Colloquium on Ocean Hydrodynamics, Turbulence in the Ocean* (1979).

CREARE INCORPORATED, P.O. Box 71, Hanover, N.H. 03755. Dr. Peter W. Runstadler, Jr., President.

041-10883-630-82

PHENOMENOLOGICAL UNDERSTANDING AND MODELING OF PUMPS

(*b*) Electric Power Research Institue.
(*c*) Dr. Peter W. Runstadler, Jr., and Mr. Walter L. Swift.
(*d*) Theoretical and experimental investigation classed as basic and applied research.
(*e*) An experimental and analytical program to provide physical understanding of fluid dynamics of multiphase flow through centrifugal pumps, to determine the adequacy of scale model testing to obtain data on pump performance under conditions of steady-state and transient two-phase flows and to develop appropriate models of pump performance in two-phase flow.
(*g*) The performance characteristics of a 1/20-scale pump have been obtained for air/water mixtures for inlet void fractions of 0.0 to 0.90. A scanning gamma densitometer system has been devloped for non-invasive void fraction measurement. Limited steady-state, steam/water, performance data have been obtained.
(*h*) **Two-Phase Flow, Pump Data for a Scale Model NSSS Pump,** P. W. Runstadler, Jr., F. X. Dolan, presented *Symp. on Polyphase Flow in Turbomachines*, Winter Annual Mtg., ASME, San Francisco, Calif., Dec. 11-14, 1978.
A Scanning Gamma Ray Attenuation System for Void Fraction Measurements in Two-Phase Flows, W. L. Swift, F. X. Dolan, P. W. Runstadler, Jr., presented *Symp. Polyphase Flow in Turbomachines*, Winter Annual Mtg., ASME, San Francisco, Calif., Dec. 11-14, 1978.
Investigations Into the Two-Phase Flow Behavior of Centrifugal Pumps, B. R. Patel, P. W. Runstadler, Jr., presented *Symp. Polyphase Flow in Turbomachines*, Winter Annual Mtg., ASME, San Francisco, Calif., Dec. 11-14, 1978.
Creare/EPRI 1/20-Scale Pump Loop Flow Regime Studies, P. W. Runstadler, Jr., F. X. Dolan, T. B. Alexander, *Electric Power Research Inst. Rept. No. NP-353*, Apr. 1977.
1/20-Scale Model Pump Test Program-Facility Description Report, P. W. Runstadler, Jr., F. X. Dolan, *Electric Power Research Inst. Rept. No. NP-293, Nov. 1977.*
1/20-Scale Model Pump Test Program-Preliminary Test Plan, P. W. Runstadler, Jr., F. X. Dolan, *Electric Power Research Inst. Rept. No. NP-292*, Feb. 1977.
Cold Leg ECC Flow Oscillations, P. H. Rothe, G. B. Wallis, D. E. Thrall, *Electric Power Research Inst. Rept. No. NP-282*, Nov. 1976.
Review and Analyses of State-of-the-Art of Multiphase Pump Technology, P. W. Runstadler, Jr., *Electric Power Research Inst. Rept. No. NP-159*, Feb. 1976.
First-Order Pump Surge Behavior, P. H. Rothe, P. W. Runstadler, Jr., presented ASME, Winter Annual Mtg., Atlanta, Ga., Nov. 28-Dec. 1, 1977. To be published in *J. Fluids Engineering*.

041-10884-630-70

EVALUATION OF DESIGN MODIFICATIONS TO A HYDROELECTRIC PLANT DRAFT TUBE

(*b*) Private industry.
(*c*) Dr. D. Japikse, President, Fluid Machinery Division.
(*d*) The investigation was an experimental, applied research and design activity.
(*e*) To experimentally evaluate an existing hydroelectric plant draft tube and to consider design modifications. Various modifications were proposed and evaluated for the particular draft tube. Project results were reported to the client for possible incorporation on a retrofit basis.
(*f*) Completed.
(*g*) Levels of performance improvements were obtained which would yield attractive economic returns, when compared to installation costs.

041-10885-630-70

EXPERIMENTAL AUDIT OF EXISTING INDUSTRIAL WATER PUMPS

(*b*) Private industry.
(*c*) Dr. D. Japikse, President, Fluid Machinery Division, or Mr. J. Goebel.
(*d*) The investigation was an experimental applied research and design activity.
(*e*) An experimental and analytical evaluation was carried out of a series of water pumps produced by a major pump manufacturer. Opportunities for improving the pump performance were isolated and reported. Different development strategies were recommended depending on the pump specific speed.
(*f*) Completed.
(*g*) The study results indicated that substantial performance gains could be obtained if advanced design concepts were introduced in a new product line. Particularly, alternative fabrication techniques were recommended that might lead to reduced costs and would certainly lead to improved performance.

041-10886-130-70

AERODYNAMIC BEHAVIOR OF LIQUID SPRAYS

(*b*) Private industry.
(*c*) Dr. P. H. Rothe or Dr. James A. Block, President Multiphase Division.
(*d*) A combined experimental and analytical study, also involving critique of vendor design.
(*e*) To assess, and if possible improve, an existing spray nozzle design used in a nuclear power plant, and secondly to summarize and upgrade methods to predict spray distributions in elevated pressure air-water and steam-water environments.
(*f*) Completed.
(*g*) Design recommendations were made and implemented while the client's plant was down three weeks for repairs. Methods to predict the interaction of gas aerodynamics with liquid spray distribution were developed. Available experimental data were synthesized by comparison with the analysis. Novel instrumentation methods were identified and assessed experimentally.
(*h*) **Aerodynamic Behavior of Liquid Sprays,** P. H. Rothe, J. A. Block, *Intl. J. Multiphase Flow* **3,** Mar. 1977.

041-10887-

UNSTABLE FLUID-STRUCTURE BEHAVIOR IN FLUID HANDLING SYSTEMS

(*b*) Numerous industrial and government clients.
(*c*) Dr. J. A. Block, President, Multiphase Division.
(*d*) Numerous projects conducted in this general area range from applied research to design.
(*e*) Selected applications have included the flow instability and vibration of pumps in systems with gas compliance or two phase flow; waterhammer in power plant piping systems, particularly where it has arisen from rapid void collapse; flow pressure and temperature oscillations and structural impacts arising from the periodic motion of water slugs in piping systems; rapid collapse of steam voids leading to pressure wave transmission and structural resonance arising from condensation-induced instabilities.
(*f*) Some activities completed, some in progress.
(*g*) The various activities have resulted in improved fundamental understanding, methods to predict behavior, and design fixes.
(*h*) **First-Order Pump Surge Behavior,** P. H. Rothe, P. W. Runstadler, Jr., *Trans. ASME, JFE*, Dec. 1978.
Pump-Surge Due to Two-Phase Flow, P. H. Rothe, P. W. Runstadler, Jr., presented ASME Winter Ann. Mtg., 1978, *ASME H00123*, 1978.
Waterhammer in the Feedwater Systems of PWR Steam Generators, P. H. Rothe, G. B. Wallis, C. J. Crowley, presented ASME Winter Ann. Mtg. 1978; in *Fluid Transients and Acoustics in the Power Industry, ASME H00120*, 1978.
Cold Leg ECC Oscillations, P. H. Rothe, G. B. Wallis, J. A. Block, presented ASME Winter Ann. Mtg. 1977; in *Symp. Thermal and Hydraulic Aspects of Nuclear Reactor Safety* **1**, *ASME G00127*, 1977.

041-10888-340-52

REFILL EFFECTS PROGRAM

(*b*) Atomic Energy Commission and Nuclear Regulatory Commission.
(*c*) Dr. P. H. Rothe or Dr. J. A. Block, President Multiphase Division.
(*d*) Theoretical and experimental investigation classed as basic and applied research.
(*e*) An experimental and analytical program has been undertaken to describe individual phenomena occurring during the refill phase of a loss of coolant accident in a pressurized water reactor. These processes include "flooding" hold up of ECC liquid, fluid-thermal interactions due to superheated walls, condensation, entrainment, boiling, and flashing.
(*g*) Data have been obtained from over 2000 tests in a 1/15 scale model of a reactor vessel, and from a number of related flow visualization and auxiliary systems. Analysis and semi-empirical models have been constructed to synthesize these data. A novel instrumentation system has been developed to acquire and display the distribution of phases, void fractions, and interfacial velocities in steam-water systems.
(*h*) **Summary of FY78 Progress; Quarterly Progress Report,** P. H. Rothe, C. J. Crowley, U.S. Nuclear Regulatory Commission, *Creare TN-291*, Jan., 1979.
Flow Topographies in Steam Water Countercurrent Flow, C. N. Cary, J. A. Block, presented ASME Winter Ann. Mtg.; in *Measurements in Polyphase Flows, ASME H00121*, 1978.
Heat Transfer Limited by Transient Flooding, C. J. Crowley, P. H. Rothe, presented *Symp. Non-Equilibrium Interfacial Transport Processes*, 18th ASME National Heat Transfer Conf., Aug. 1979.
Condensation-Driven Fluid Motions, J. A. Block, presented *EPRI Workshop on Basic Two-Phase Flow Modeling*, Fla., Mar. 1979.

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DARTMOUTH COLLEGE, Thayer School of Engineering, Hanover, N.H. 03755. Graham B. Wallis, Professor of Engineering, Horst J. Richter, Research Associate Professor of Engineering, Desikan Bharathan, Research Assistant Professor of Engineering.

042-09789-130-73

THE SEPARATED FLOW MODELS OF TWO-PHASE FLOW

(*b*) Electric Power Research Institute.
(*d*) Theoretical and experimental basic research.
(*e*) Establishment of a unified basic theory.
(*h*) **The Separate Flow Model of Two-Phase Flow,** G. B. Wallis, H. J. Richter, J. T. Kuo, *EPRI NP-275*, Dec. 1976.
Isentropic Streamtube Model for Flashing Two-Phase Vapour Liquid Flow, G. B. Wallis, H. J. Richter, *J. Heat Transfer* **100,** 595-600 (1978).
Air-Water Countercurrent Flow in Vertical Tubes, D. Bharathan, G. B. Wallis, H. J. Richter, *EPRI Rept. NP-786*, May 1978.
Interphase Momentum Transfer in the Flow of Bubbles Through Nozzles, J. T. Kuo, G. B. Wallis, H. J. Richter, *EPRI Rept. NP-980, Feb. 1979.*

042-09790-130-55

EFFECT OF SCALE ON TWO-PHASE COUNTERCURRENT FLOW FLOODING IN VERTICAL TUBES

(*b*) NRC.
(*c*) H. J. Richter.
(*d*) Theoretical and experimental basic research.
(*e*) Obtain data on flooding in various scales.
(*h*) **Effect of Scale on Two-Phase Countercurrent Flow Flooding,** H. J. Richter, G. B. Wallis, M. Speers, *NUREG/CR-0312*, June 1978.

042-09791-130-55

TECHNICAL ASSESSMENT OF TWO-PHASE FLOW ASPECTS OF NUCLEAR REACTOR SAFETY

(*b*) NRC.
(*d*) Theoretical and experimental modeling of two-phase flow phenomena.
(*h*) **Two-Phase Flow in a Model Pressurized Water Reactor Equipped with Vent Valves,** G. B. Graham, D. L. Ludwig, G. B. Wallis, H. J. Richter, *NRC-0193-1*, Sept. 1977.
Countercurrent Two-Phase Flow in Parallel Vertical Channels, Y. Hagi, G. B. Wallis, H. J. Richter, *NRC-0193-2*, Sept. 1977.
Steam Flow Split Prediction and Water Penetration Characteristics in a Hot-Leg–Cold Leg Loop, D. E. Pavlakis, H. J. Richter, G. B. Wallis, *NRC-0193-3*, Sept. 1977.
Pressurized Water Reactor Upper Head Injection Air-Water 1/30 Scale, Entrainment Studies, A. Porteous, H. J. Richter, C. Stone, *NRC-0193-4*, Sept. 1977.
Flooding in Multi-Path Vertical Countercurrent Air-Water Flow, C. R. Clark, G. B. Wallis, H. J. Richter, D. Bharathan, *NRC-0193-5*, Sept. 1978.
Effects of Bottom Orificing on Single- and Multi-Tube Countercurrent Flow Characteristics, D. Bharathan, G. B. Wallis, H. J. Richter, *NRC-0193-6*, Sept. 1978.
Lower Plenum Voiding, D. Bharathan, G. B. Wallis, H. J. Richter, M. Ayalew, *NRC-0193-7*, Sept. 1978.
Countercurrent Air-Water Flow in Parallel Vertical Tubes of Small Diameter, A. S. Karlin, G. B. Wallis, D. Bharathan, *NRC-0193-8*, Sept. 1978.
Deentrainment and Countercurrent Air-Flow in a Model PWR Hot Leg, H. J. Richter, Sept. 1978.

042-10889-130-54

MECHANISMS OF BUBBLE TRANSPORT IN TURBULENT TWO-PHASE FLOW

(*b*) NSF.
(*c*) H. J. Richter.

(*d*) Basic theoretical and experimental research.
(*e*) Development of a theory for bubble distribution in two-phase flow.

042-10890-400-30

FINITE ELEMENT MODELING OF TIDAL CIRCULATION

(*b*) U.S.G.S.
(*c*) Daniel R. Lynch.
(*d*) Basic theoretical research.
(*e*) An investigation of numerical solution procedures for the two-dimensional shallow water equations.
(*g*) Several new analytic solutions have been generated for model testing purposes. Fourier analysis of the convergence, stability and accuracy of several timestepping schemes has been achieved. Efficient models based on a new wave equation formulation have been evaluated. A comparison of time-stepping models with continuous-time models is underway. Extension to problems with moving boundaries has been demonstrated.
(*h*) **Alternative Time Stepping Schemes for Finite Element Tidal Computations,** W. G. Gray, D. R. Lynch, *Advances in Water Resources* I, 2 (Dec. 1977).
Analytic Solutions for Computer Flow Model Testing, D. R. Lynch, W. G. Gray, *J. Hydraulic Division, ASCE*, Oct. 1978.
On the Control of Noise in Finite Element Tidal Computations: A Semi-Implicit Approach, W. G. Gray, D. R. Lynch, *Computers and Fluids* **7**, 1 (March 1979).
A Wave Equation Model for Finite Element Tidal Computations, D. R. Lynch, W. G. Gray, *Computers and Fluids*, (in press 1979).

042-10891-810-15

IMPACT OF SOIL MOISTURE CONDITIONS ON WATERSHED BEHAVIOR IN COLD REGIONS

(*b*) U.S. Army Cold Regions Research & Engineering Laboratory.
(*c*) Daniel R. Lynch.
(*d*) Basic research, theoretical and experimental.
(*e*) Importance of soil moisture and frozen ground are being investigated by comparison of field investigations with results predicted by existing watershed models. Improvements to these models will be suggested and tested where necessary.

042-10892-000-00

FINITE ELEMENT SIMULATION OF MOVING BOUNDARY PROBLEMS

(*c*) Daniel R. Lynch.
(*d*) Basic theoretical research.
(*e*) Development and application of a general FE procedure for dealing with moving boundary problems; applications to both hyperbolic and parabolic problems are being investigated.
(*g*) Successful simulation of one-dimensional Stefan-type problems (both one- and two-phase) has been achieved. Two-dimensional simulation of a hyperbolic problem which arises in tidal flooding has also been demonstrated.
(*h*) **Finite Element Simulation of Shallow Water Problems with Moving Boundaries,** D. R. Lynch, W. G. Gray, *2nd Intl. Conf. Finite Elements in Water Resources,* Imperial College, London, July 1978.
A Finite Element Solution for Porous Medium Freezing, Using Hermite Basis Functions and a Continuously Deforming Coordinate System, K. O'Neill, D. R. Lynch, *Proc. Intl. Conf. Numerical Methods in Thermal Problems*, (Swansea, July 1979).

UNIVERSITY OF DETROIT, College of Engineering, Civil Engineering Department, 4001 W. McNichols Road, Detroit, Mich. 48221. Dr. Eugene Kordyban, Associate Professor.

043-07979-130-00

INVESTIGATION OF THE MECHANISM OF SLUG FORMATION IN TWO-PHASE HORIZONTAL FLOW

(*d*) Experimental and theoretical basic research.
(*e*) Basic nature of wavy and stratified air-water flow is being studied theoretically and experimentally to determine the conditions under which the slugs will form.
(*g*) The wave characteristics such as speed, height to length ratio and the internal flow patterns have been determined experimentally. The wave growth as a function of water depth and air velocity has been established. The criteria for slug formation as a result of wave instability have been found theoretically.
(*h*) **The Transition to Slug Flow in the Presence of Large Waves,** E. Kordyban, *Intl. J. Multiphase Flow* **3**, 1977.
Growth of Interfacial Waves in Closed Horizontal Channels, E. Kordyban, *ASME Paper 78-WA/FE-8*.
A Method for Measuring Pressure at the Wave Surface, E. Kordyban, S. Cuker, accepted for publication by *Rev. of Scientific Instruments*.

043-09924-870-00

A STUDY OF THE BEHAVIOR OF AN OIL FILM ON THE SURFACE OF WATER IN THE PRESENCE OF WAVES

(*d*) Basic research, theoretical and experimental.
(*e*) The behavior of a layer of oil on the surface of water in the presence of water is investigated experimentally and analytically.
(*g*) An instrument to measure the oil thickness in the presence of waves has been developed and tested. Preliminary tests show the oil to be thicker at the wave crests in agreement with analysis.
(*h*) **Instrumentation to Measure the Oil Thickness on a Wavy Water Surface,** E. Kordyban, S. Cuker, *Rev. Sc. Inst.* **49,** 9 Sept. 1978.

DREXEL UNIVERSITY, College of Engineering, Philadelphia, Pa. 19104.

044-11497-050-22

INCOMPRESSIBLE FREE AND IMPINGING JET FLOW PROBLEMS

(*b*) Naval Air Engineering Center, Lakehurst, N.J.
(*c*) Dr. F. K. Tsou, Professor, Department of Mechanical Engineering, or Dr. Jack C. Hwang, Asst. Professor, Department of Civil Engineering.
(*d*) Basic and applied research.
(*e*) Conduct literature search on jet spread, velocity profiles, temperature profile, pressure distribution and heat transfer characteristics of impinging jet. Undertake mathematical modeling of the effects of free stream, oblique impingement, and air entrainment in the jet flows.

DUKE UNIVERSITY, Department of Mechanical Engineering and Materials Science, Durham, N.C. 27706. Dr. Jack B. Chaddock, Chairman.

045-10893-690-84

INVESTIGATION OF EFFECT OF OIL ON HEAT TRANSFER AND PRESSURE DROP IN REFRIGERANT EVAPORATORS

(*b*) American Society of Heating, Refrigerating and Air Conditioning Engineers.
(*c*) Dr. Jack B. Chaddock.
(*d*) Experimental.

(*e*) To collect experimental data which will permit the determination of pressure drop and "local" heat transfer coefficients for refrigerants evaporating in a multi-pass horizontal tube evaporator, when oil is circulated with the refrigerant. To make a comprehensive review of the published information on pressure drop and heat transfer during evaporation in tubes, and present the data and correlation equations or graphs judged to be the more promising for application by refrigeration engineers. To examine the available information on the influence of oil on refrigerant evaporator performance, and organize it for application to refrigeration systems. Based on the results of these items above, to develop generalized calculation procedures for pressure drop and heat transfer coefficients that will account for the effects of the presence of small percentages of oil in a refrigerant evaporator. Phase 1 (1st year) will collect data on fluorinated hydrocarbon refrigerant R-502 using Suniso 3GS oil. Phase 2 (2nd year) will collect data on ammonia R-717 in the presence of Capello D Oil.

(*g*) Testing to determine best method of attaching thermocouples to copper tube surfaces carried out. Laying of thermocouple wires in surface grooves with thermal epoxy bond judged as most stable. Tests gave accurate temperatures with this method. Refrigeration system layout completed. Oil loops with measurement methods installed and tested–complete. Test evaporator box constructed and installed in place. Mounting of thermocouples on evaporator in progress. Detailed review of oil-in-refrigerant data collected at Duke University under an ASHRAE Grant-in-Aid completed.

045-10894-270-40

TOTAL HEAT LOSS DUE TO RESPIRATION OF NEONATES

(*b*) National Institutes of Health.
(*c*) Dr. C. E. Johnson.
(*d*) Experimental, basic research, design; Doctoral thesis.
(*e*) A thermodynamic analysis of respiration describes the sensible and insensible heat loss in terms of respiratory gas temperatures, component concentrations of oxygen, carbon dioxide, nitrogen, and water vapor, volume flow rates, respirant mixture density, specific heat, and psychrometric parameters. An instrumentation system for measuring these parameters from neonates in the normal hospital nursery has been developed. A nasal mask, one-way valves and breathing circuit especially designed to permit the measurement of respiratory gas volumes by pneumotachometer with a minimum of alteration in the normal breathing effort has been designed. The testing procedures have been established and test results of this system have been obtained. The procedures for measuring respiratory gas temperatures and component concentrations of the expired gas have been established. The thermal state of the infant is described in terms of the body core temperature, the ambient temperature, and the fluctuations of skin temperatures from six distinct skin surface sites. A multiplexor unit has been designed which accomplishes the automatic switching between temperature sensors, recording sequentially and periodically all temperatures during the data collection. The multiplexor is also capable of being controlled by a microcomputer unit.
(*g*) See (e).
(*h*) **A Breathing Mask for the Measurement of Respiratory Function in Neonates,** C. E. Johnson, R. K. Samras, L. R. Blackmon, *Advances in Bioengineering*, A. Burstein, Ed., ASME, N.Y, 1978.

045-10895-700-00

A SUBMERSIBLE LASER-DOPPLER VELOCIMETER FOR GEOPHYSICAL FLOWS

(*c*) Dr. Edward J. Shaughnessy, Asst. Professor.
(*d*) Experimental and field investigation.
(*e*) A submersible laser-Doppler anemometer using a 5 mW He-Ne laser has been designed for use in studies of turbulent velocity fluctuations in natural waters.
(*g*) Field observations with the laser probe indicate that good performance can be obtained when measuring low speed currents. Nearly continuous signals have been observed in seawater, indicating a satisfactory particle content for the laser scattering process.

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GENERAL DYNAMICS CORPORATION, ELECTRIC BOAT DIVISION, Eastern Point Road, Groton, Conn. 06340. J. R. Hunter, Director of Engineering.

046-09846-210-00

PNEUMATIC AND HYDRAULIC TRANSIENTS IN SUBMARINE PIPING SYSTEMS

(*c*) Bernard S. Ryskiewich, Engineering Specialist, Systems Technology Department.
(*d*) Theoretical applied research.
(*e*) Two computer programs, HYTRN and PNUTRN, have been developed to calculate unsteady flow transients in complex submarine piping systems containing assorted piping components. HYTRN applies to liquid systems while PNUTRN applies to gas systems and is presently coded for air and steam. The method of characteristics with fixed time steps is employed in each program. The programs are applicable to systems containing system components and boundary components presently available in their respective program libraries.
(*f*) The project is complete, and recommendations are to introduce a cavitation model into HYTRN.

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GENERAL ELECTRIC COMPANY, CORPORATE RESEARCH AND DEVELOPMENT, Research and Development Center, P.O. Box 8, Schenectady, N.Y. 12301.

047-10896-630-00

FINITE ELEMENT FLOW ANALYSIS OF THREE-DIMENSIONAL FLOW IN TURBOMACHINES

(*c*) Dr. T. E. Laskaris, Manager, Rotating Machinery Unit.
(*d*) Theoretical, applied research.
(*e*) The program aims at developing finite-element algorithms capable of solving the steady-state hydrodynamic equations of the three-dimensional compressible inviscid flow in rotating or stationary flow regions. The studies investigate potential flows and rotational flows in turbomachinery cascades including shock wave discontinuities.
(*g*) A finite-element algorithm was developed to analyze three-dimensional compressible potential flows in turbomachinery rotor/stator cascades. The algorithm is based on Galerkin's method applied over distorted curvilinear elements of the flow region. The absolute velocity potential is approximated by second order Lagrange polynomials and nodal parameters. The process reduces the problem to a system on nonlinear algebraic equations solved by the Newton-Raphson iteration scheme. The method was applied to a mixed-flow type of turbine rotor blade-row in subsonic flow of peak Mach number near unity. A turbine stator blade row was also analyzed and a locally supersonic "bubble" at the suction side of the blades was well resolved and characterized. Computation time in the DEC VAX 11/780 minicomputer is typically 45 minutes for a grid size of 1500 nodes.
(*h*) **Finite Element Analysis of Three-Dimensional Potential Flow in Turbomachines,** T. E. Laskaris, *AIAA Journal* **16**, 7, July 1978.

047-10897-340-00

HYDRO COMPRESSORS

(*c*) W. B. Giles, K1-Combustion Bldg; Dr. H. K. Liu, Manager Mechanical Systems and Technology Laboratory.
(*d*) Analytic and experimental design study.

(e) Concept system development and assessment is being conducted of a combined power generation cycle consisting of a hydraulic compressor, gas turbine-generator, and regenerator.

(g) Assessment of run-of-stream operation for existing U.S. dams indicates significantly lower cost-of-electricity than competing generation cycles in the region of capacity factors of 20-50 percent.

047-10898-030-52

FLOW INDUCED VIBRATION FOR LIGHT WATER REACTORS

(b) DoE as a subcontract to GE BWRSD.

(c) S. Savkar.

(d) Basic experimental and theoretical research into the unsteady flow/structural interaction of cylinders and cylindrical arrays.

(e) This project involved three phases. In the first phase, a measurement scheme for directly measuring the unsteady random loads on cylinders using piezoelectric load cells was developed. As a part of this effort, the phenomenology of buffeting of cylinders immersed in turbulent flows was examined. Tests were conducted in both air and water and spanned a range of Reynolds 2×10^4 to 2×10^6. Turbulence was generated by grids. Turbulence parameter range included intensities up to about 10 percent and integral scale to cylinder diameter ratios between 1/3 to 3/2. Limited data on two inline cylinders was also obtained. This phase of the work was to have been followed by an examination of cylindrical arrays in the second phase. This work was motivated by the concern for buffeting or control guide tubes in LWR's. The third phase involved the examination of self-induced vibrations of tube arrays such as encountered in heat exchangers. A theoretical model for the instability was developed.

(f) Discontinued half way as of September 1978.

(g) In the area of buffeting, for an isolated cylinder: 1) Discovered that a transition from a subcritical to a supercritical regime exists in a manner analogous to the steady drag. 2) Discovered that the Strouhal frequency characterizes the time scale of buffeting. 3) Steady lift coefficient bounds the unsteady lift coefficient in buffeting. In the problem of array instability, a first principle model based on energy consideration was developed. This result appears to better fit published data trends.

(h) **Buffeting of Single Cylinders,** S. Savkar, R. M. So, *BNES Vibration in Nuclear Plant Conference*, Keswick, U.K., May 1978.

On the Buffeting Response of a Cylinder in a Turbulent Cross Flow, S. Savkar, *GE-NEED Contractor Report, GEAP-24147*, Sept. 1978.

GENERAL MOTORS CORPORATION, HARRISON RADIATOR DIVISION, Lockport, N.Y. 14094. Ramesh K. Shah, Technical Director of Research.

048-10901-210-20

LAMINAR FLOW FORCED CONVECTION IN DUCTS

(b) Stanford University, Stanford, California, and the Office of Naval Research.

(c) Dr. R. K. Shah, Technical Director of Research.

(d) Analytical (theoretical and some experimental results), basic research.

(f) Completed.

(g) This monograph presents an up-to-date compilation of analytical solutions for laminar fluid flow and forced convection heat transfer in circular and noncircular pipes. The solutions are summarized for both developed and developing laminar flows of a Newtonian fluid with constant properties. The solutions in terms of friction factors and Nusselt numbers as well as velocity and temperature profiles are presented extensively in tabular and graphical forms; some solutions are approximated by equations. In all, over 200 solutions are summarized for 40 duct geometries from 95 worldwide technical journals and proceedings, as well as from unpublished technical reports and theses.

(h) **Laminar Flow Forced Convection in Ducts,** R. K. Shah, A. L. London, Academic Press, New York (1978).

GEORGIA INSTITUTE OF TECHNOLOGY, School of Civil Engineering, Atlanta, Ga. 30332. J. E. Fitzgerald, Director.

049-10900-340-54

A NUMERICAL MODEL OF THE INTERACTION OF DENSITY CURRENTS AND WIND-INDUCED MIXING IN STRATIFIED COOLING LAKES

(b) National Science Foundation.

(c) Dr. T. W. Sturm, Asst. Professor.

(d) Theoretical and field investigation; basic research.

(e) Vertical mixing of heat in a stratified cooling lake by wind is modeled by energy balance considerations. Superimposed on this layered model of the lake is a density current model which predicts horizontal temperature gradients and the associated surface heat loss. The purpose is to assess the relative influence of density currents and wind-induced mixing on the thermal structure of a natural lake used for cooling water by a power plant.

049-11640-350-00

FLOW OVER SPILLWAYS

(c) Dr. M. M. Aral and Dr. P. G. Mayer.

(d) Analytical; applied research.

(e) A finite element numerical model is used to predict the flow characteristics for flow over spillways. Velocity and pressure distributions on spillway profiles and head discharge relations for characteristic spillways are investigated.

049-11641-050-00

JET IMPINGEMENT ON STRAIGHT AND CURVED SURFACES

(c) Dr. M. M. Aral and Dr. P. G. Mayer.

(d) Analytical; basic research.

(e) Two-dimensional and axisymmetric jet deflection problem is studied using a finite element model. Contraction coefficients and jet deflection angles are evaluated for various geometries.

049-11642-820-00

THE FATE OF GROUNDWATER POLLUTION BY NUCLEAR (AS WELL AS OTHER HAZARDOUS) WASTES

(c) Dr. M. M. Aral and Dr. P. G. Mayer.

(d) Analytical; applied research.

(e) The fate of hazardous liquid wastes in a groundwater environment is studied. Analysis includes aspects of radioactive materials accidentally released from nuclear power plants, nuclear fuel reprocessing plants, or nuclear waste storage areas. Governing mathematical models are analyzed numerically using the finite element method.

049-11643-820-00

ANALYSIS OF THE DEVELOPMENT OF SHALLOW GROUNDWATER SUPPLIES BY PUMPING FROM PONDS

(c) Dr. M. M. Aral and Dr. T. W. Sturm.

(d) Analytical; applied.

(e) Development of shallow groundwater supplies by pumping from ponds is being investigated with a finite element numerical model of the groundwater hydraulics. The research is specifically related to the development of the shallow aquifer in the Georgia coastal plain to relieve the present demand on the deeper principal artesian aquifer.

049-11644-420-70

WAVE RUNUP ON FLOOD PROTECTION LEVEE

(*b*) Exxon.
(*c*) Dr. C. S Martin.
(*d*) Experimental; applied.
(*e*) A hydraulic model study was conducted to investigate wave runup on the Flood Protection Levee at the Baytown Marine Terminal. The purpose of the tests was to assess the effectiveness of Gobi-Mats on the slope as well as to investigate the number, arrangement, and location of tetrapods on the slope. Impact pressures on a vertical sea wall were measured for various wave amplitudes.

049-11645-340-73

HYDRAULIC MODEL STUDY OF TUNNEL TRIFURCATION

(*b*) Georgia Power Company.
(*c*) Dr. C. S. Martin.
(*d*) Experimental; applied.
(*e*) Scaled models of four designs of a three unit trifurcation scheme of a pumped-storage project were tested for head-loss comparisons and observation of flow patterns. Head-loss coefficients were measured for a variety of pumping and generating modes.

049-11646-340-82

FIELD STUDY AND ANALYSIS OF FLUID TRANSIENTS IN LARGE SCALE COOLING WATER SYSTEMS

(*b*) Electric Power Research Institute.
(*c*) Dr. C. S. Martin.
(*d*) Experimental and analytical; applied research.
(*e*) Transient presures and flows will be measured simultaneously in the Circulating Water System of the Shoreham Nuclear Power Station, owned by Long Island Lighting Company. Drag-type flow meters will be employed on the centerline of the conduit to monitor the transient flow subsequent to intentional tripping of the pumps. Tests will be conducted with and without vacuum breaker operation and with and without air injection. Analytical models will be developed and compared with the field data. The models will include whenever possible the two-phase aspects of the flow in the discharge conduits and in the condensor tubes and water box as well.

049-11647-130-54

TRANSIENT TWO-PHASE SLUG FLOW

(*b*) National Science Foundation.
(*c*) Dr. C. S. Martin.
(*d*) Experimental and analytical; basic research.
(*e*) The simple model of pressure pulse propagation in slug flow proposed by Henry, Grolmes, and Fauske has been extended by considering wave transmission at gas-liquid interfaces. A frequency-response model applied to a series of idealized gas and liquid slugs yields a pulse propagation speed that approaches the homogeneous model value as the number of slugs is increased for a given void fraction. All characteristic roots from the solution to a three-equation drift-flux model are related to the velocity of the center of mass of the mixture. The pulse propagation speed relative to this velocity is exactly equal to the homogeneous model value, however. Measured pulse propagation speeds in vertically downward slug flow are, as anticipated, much less than those predicted by the simple model of Henry, Grolmes, and Fauske, but slightly greater than the homogeneous model value. Measured pressure surges produced by the rapid closure of a downstream valve in a pipeline are reasnably well predicted by the drift-flux model. For the range of void fractions, pressures, and velocities encountered in this study, it is concluded that pressure pulse speeds and the magnitude of pressure surges in slug flow can be adequately predicted by a homogeneous model.
(*h*) **Pressure Pulse Propagation in Two-Component Slug Flow,** *J. Fluids Engrg.* **101**, Mar. 1979, pp. 44-52.

049-11648-230-26

CAVITATION DAMAGE MECHANISMS

(*b*) U.S. Air Force (AFOSR).
(*c*) Dr. C. S. Martin.
(*d*) Experimental; basic research.
(*e*) The inception of and extent of cavitation in directional control valves has been investigated in a laboratory apparatus using hydraulic oil as the test fluid. Tests have been conducted with a metal valve. For each valve mean chamber pressure, temperature, flow rate, valve position, and upstream, differential and downstream pressures have been monitored. Piezoelectric pressure transducers and an accelerometer were used to detect the onset as well as the extent of cavitation for various values of the cavitation index.
(*g*) The incipient cavitation number is dependent upon the Reynolds number. The effect of dissolved gas is minimal for dissolved gas content 9 percent (by volume) or less.

049-11649-870-54

MATHEMATICAL MODELING OF WASTEWATER DISPERSION IN COASTAL WATERS

(*b*) National Science Foundation.
(*c*) Dr. P. J. W. Roberts.
(*d*) Analytical; applied research.
(*e*) A mathematical model is being developed to use current meter data collected from many spatially separated continuously recording current meters to predict the dispersion of wastewater discharged from ocean outfalls.

049-11650-340-10

JET ENTRAINMENT DESCRIPTION FOR THERMAL MODELING OF PUMPED-STORAGE RESERVOIRS

(*b*) U.S. Army Corps. of Engineers.
(*c*) Dr. P. J. W. Roberts.
(*d*) Analytical; applied research.
(*e*) The mechanism of entrainment caused by the jet issuing into a pumped storage reservoir is being investigated. Means to predict the entrained volume and levels of the density stratified reservoir from which the entrainment comes are sought. The results will be incorporated into a mathematical model of the reservoir.

GRUMMAN AEROSPACE CORPORATION, Bethpage, N.Y. 11714.

051-10902-700-36

STORM AND COMBINED SEWER FLOWMETER

(*b*) Municipal Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency.
(*c*) K. M. Foreman, Branch Head, Advanced Fluid Concepts.
(*d*) Theoretical end experimental applied research.
(*e*) This is an investigation of a new, nonintrusive, low cost, passive flow measurement method for advance management approaches to storm and combined sewer systems. The technique is based on sensing the near field sound emitted by the sewer flow at a channel discontinuity disturbance; such discontinuities are significant changes in channel cross sectional or flow direction. The acoustic emission is a partial transformation of the flow energy. The output of passive sensors, such as accelerometers, attached to non-wetted surfaces of the sewer channel is related to flow rate by the amplitude of signal in a narrow ($\sim$100 to 200 Hz) band around a characteristic center frequency in the sub-ultrasonic to mid-audible range. Laboratory and field tests have been conducted to provide empirical constants for the theoretical analysis.
(*g*) In the earlier laboratory phase during 1975, basic feasibility of the concept was demonstrated by water flow tests using full scale sewer pipe elements. Corroborative data

was obtained, using a laboratory prototype measurement system, for simulated buried installations of the pipes and with water containing suspended and settleable solids characteristic of sewage concentration levels. Open channel, full flow, and pressurized flow conditions were produced in a research facility at rates up to 15.4 pounds per second. The acoustic signal at the characteristic frequency increases with flow; at low flow rates, according to the ideal dipole theoretical prediction of 12 decibels per doubling of flow rate. At the intermediate to high laboratory flow rates, the signal increases more nearly linearly with flow rate. Three field site investigations during 1977 and 1978 of storm water flow have extended this test range to flow rates up to 7500 gpm and 60 inch (1.5 m) diameter channels. Measured sound power, in decibels, has been found related to mass flow rate to the 1.4 to 1.7 power, depending on channel discontinuity. A manhole is suitable for sensor installation. Small scale ($\sim$1/20th) geometric models appear to simulate fairly well the sound intensity to flow rate relationship of full scale sites according to a theoretical scaling law, thus, precluding field site calibration requirements.

(*h*) **A Passive Flow Measurement System for Storm and Combined Sewers,** K. M. Foreman, *Report EPA-600/2-76-115*, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268. May 1976.
A Passive Flow Measurement Technique for Unsteady Nonhomogeneous Fluid Flow, K. M. Foreman, *Proc. 24th Intl. Instrumentation Symp.* **24,** 1, pp. 275-280, May 1978, ISA, Pittsburgh, Pa.
Field Testing of Prototype Acoustic Emission Sewer Flowmeter, K. M. Foreman, *Grumman Research Department Report RE-566*, Jan. 1979, Grumman Aerospace Corporation, Bethpage, N.Y. 11714.

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HARVARD UNIVERSITY, Division of Applied Sciences, Cambridge, Mass. 02138. Professors Myron B. Fiering, Peter Rogers, Joseph J. Harrington.

052-10112-880-54

MANAGEMENT AND STANDARDS FOR ECOSYSTEMS

(*b*) National Science Foundation.
(*d*) Theoretical, applied, one Doctoral thesis derived.
(*e*) An ecosystem is modeled to show that the concept of *system resilience*, a measure of the system's ability to absorb perturbations and recover, is a useful parameter for system design. A further inquiry is directed at the role of compressing large-scale simulation studies into a scale appropriate for policy analysis. An example of a forest management system is given.
(*g*) Policy analysis by compression appears a feasible procedure when certain structural characteristics of the problem specifications are met. It is shown that the amount and frequency of insecticide spraying for forest-pest management can significantly be reduced if spray is initiated at *low* levels of larval density.
(*h*) **The Spruce Budworm Management Models,** *Thesis*, J. Stedinger, 1977.

052-10113-800-33

STANDARDS, OPTIMALITY AND RESILIENCE IN WATER-RESOURCE MANAGEMENT

(*b*) OWRT, Department of the Interior.
(*c*) Professors Harrington, Rogers and Fiering.
(*d*) Theoretical, applied.
(*e*) A systematic effort to study the role of complexity, redundancy and robustness of mathematical models used in the design and operation of "optimal" or "near-optimal" water-resource systems. A case study from the Connecticut River Basin will be taken.
(*g*) Preliminary results suggest that many mathematical models for water-resource system design are too detailed and too complex for the data bases and policy options typically available.
(*h*) **Climatic Variability and the Impact of Possible Future Climatic Changes on Water Supply in Use,** M. B. Fiering, N. Matalsa, Amer. Geophys. Union, Wash. D.C., NAS, 1977.
The Role of Systems Analysis in Water Program Development, M. B. Fiering, *Natural Resources Journal*, Univ. New Mexico School of Law, 1976, pp. 12.
On The Choice of the Appropriate Model for Water Resources Planning and Management, P. Roger, *Water Resources Research* **14,** 6, Dec. 1978, pp. 7.
Draft Report, M. B. Fiering, P. Rogers, J. J. Harrington, Harvard University, Mimeo, Dec. 1978.

052-10903-880-80

ENVIRONMENTAL IMPACT OF DEVELOPMENT PROJECTS: A CASE STUDY ON THE KOSI

(*b*) International Environment Program, Ford Foundation, New York.
(*c*) Professor Peter Rogers.
(*d*) Theoretical, applied research.
(*e*) An investigation of the environmental impacts of development projects. An attempt to view these impacts over the construction, and operation phases of a project. The research hypothesis is that within a decade of the project completion additional work will be undertaken to mitigate any severe environmental impacts carried by the project in the first place.
(*h*) **Environmental Consequences of Development Projects, A Proposed Case Study of the Kosi Project,** Harvard University, Oct. 1977, Mimeo, 22 pp.

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UNIVERSITY OF HAWAII AT MANOA, Department of Civil Engineering, 2540 Dole Street, Honolulu, Hawaii 96822. Dr. John A. Williams.

053-09046-870-61

SUBSURFACE WASTE DISPOSAL BY INJECTION IN HAWAII

(*b*) Water Resources Research Center.
(*c*) Professor F. L. Peterson, Department of Geology and Geosciences, or Prof. J. A. Williams, Department of Civil Engineering.
(*d*) A theoretical and experimental study as well as field observation.
(*e*) Determine the interaction between waste water injected and the Ghyben-Herzberg system. Hele-Shaw and digital models are to be used and their results correlated with field data.
(*f*) Completed.
(*g*) The significant injection parameters proved to be the rate of effluent injection, the strength of the ambient flow field and the depth of injection. The principal means of plume movement in these experiments appeared to be by fluid displacement rather than by a dispersion process. This was the case for both Hele-Shaw and sand box type models.
(*h*) **A Laboratory Study of Waste Injection Into a Ghyben-Herzberg Groundwater System Under Dynamic Conditions,** D. L. Heutmaker, F. L. Peterson, S. W. Wheatcraft, *Univ. of Hawaii Water Resources Research Center Tech. Rept. No. 107.*
Waste Injection Into Stratified Broundwater Bodies, F. L. Peterson, S. W. Wheatcraft, D. L. Heutmaker, *Water and Sewage Works* **124,** 1, pp. 50-65.
Waste Injection Into the Hawaiian Ghyben-Herzberg Aquifer: A Laboratory Study Using a Sand-Packed Hydraulic Model, S. W. Wheatcraft, F. L. Peterson, D. L. Heutmaker, *Univ. of Hawaii Water Resources Research Center Tech. Rept. No. 96*, 1976.
Well Injection Into a Two-Phase Flow Field: A Hele-Shaw Model Investigation, J. A. Williams, *Univ. Hawaii Water Resources Research Center Tech. Rept. No. 108*, 1977.
Waste Injection Into a Two-Phase Flow Field: Sand Box and Hele-Shaw Models Study, F. L. Peterson, J. A. Williams, S. W. Wheatcraft, *Groundwater* **16,** 4, 1978.

UNIVERSITY OF HAWAII, J. K. K. Look Laboratory of Oceanographic Engineering, Department of Ocean Engineering, 811 Olomehani Street, Honolulu, Hawaii 96813. Eduard K. Noda, Director of the Laboratory. (Direct report requests to: The Director)

054-08121-420-60

MEASUREMENT OF OCEAN WAVE-INDUCED WATER PARTICLE KINEMATICS

(*b*) National Sea Grant Program, NOAA.
(*c*) R. A. Grace.
(*d*) Experimental project in the ocean to examine the accuracy of the predictions of the linear and stream function theories related to peak wave-induced water particle velocities and accelerations near the sea bed.
(*e*) Kinematics measured by a ducted impeller meter 1.5 feet above the bottom in 37 feet of water. Wave conditions obtained from a spiral-wound, resistance gage.
(*f*) Completed.
(*g*) Linear and stream function theories both accurate for velocities but considerably in error for accelerations.
(*h*) **Near-Bottom Water Motion Under Ocean Waves,** R. A. Grace, *Proc. 15th Intl. Conf. on Coastal Engrg.*, Honolulu, Hawaii, July 1976.

054-09277-420-44

PIPELINE SURVIVAL UNDER OCEAN WAVE ATTACK

(*b*) National Sea Grant Program, NOAA.
(*c*) R. A. Grace.
(*d*) Experimental study in the ocean to obtain wave force coefficients for a submarine pipe parallel to the wave fronts.
(*e*) Test pipe made of steel, 16 inches in diameter and 17.5 feet long. Length of instrumented section–39.5 inches. Pipe mounted on base set on bottom in 37 feet of water. Kinematics measured with a ducted current meter and wave conditions with a resistance wire gage.
(*f*) Data taking completed; final report in preparation.
(*g*) Maximum force coefficients in horizontal and vertical directions independent of Reynolds number, pipe clearance, and roughness, but correlated with modified Keulegan-Carpenter period parameter.
(*h*) **Wave Force Coefficients from Pipeline Research in the Ocean,** R. A. Grace, S. A. Nicinski, *Proc. 8th Ann. Offshore Tech. Conf.* **3**, Houston, Tex., May 1976, pp. 681-694.

054-09278-520-00

DYNAMIC RESPONSES OF MOORED SHIPS DUE TO WAVE ACTION

(*c*) L. H. Seidl and T. T. Lee.
(*d*) Experimental in the laboratory and numerical type studies as applied research and for use in Master's level papers (not thesis).
(*e*) Predict the dynamic responses of tankers moored at sea berth subjected to wave excitations from various headings. Regular and group waves were generated in a seakeeping and wave basin (42 ft wide, 64 ft long, and 4 ft high) for both deep water and shallow water conditions so as to excite spread-moored ship model at 1:100 scale of a 39,200-ton tanker and another at 1:100 scale of a 313,000-ton tanker. Ship model motions in six degrees of freedom were measured and compared with those predicted numerical for the prototypes.
(*f*) Completed.
(*g*) Agreement between numerical predictions and experimental measurements is considered good although there is some scattering of data points perhaps due to model scale, and nonlinear effects. The numerical technique is appliable to ships moored in regular waves and group waves. It predicts the slow-drift oscillations which must be taken into consideration in the design of sea berths. The test results for both water depth to draft ratio of 1.20 and 1.56 are presented in unit amplitude responses of ship motions (sway, surge, heave, pitch, roll, yaw, and slow drift oscillations) as a function of wave period. The effect of the bottom on the virtual mass and moment inertia is evident for the small water depth to draft ratio of 1.20. A Master of Science level research paper was completed covering laboratory study of a 1:100 scale model fo a 260,000-ton supertanker in a six point symmetric moor and subjected to head-on and beam-on regular and group waves for water depth to ship draft ratio of 1.2 and 1.5. Displacements in the six modes of motion were measured and steady state drift mooring forces were calculated from the measured displacements. From the data, a reflection coefficient, R, indicating the relative drift force was determined and presented in graph form as a function of incident wave period. It is found that the drift force is amplified in the vicinity of the natural period of heave, pitch and roll. Tank effects such as especially undesirable reflections from tank boundaries must be reduced to a minimum for similar tests.
(*h*) **SEABERTH–A Program for Calculation of Motions and Mooring Forces,** L. Sugin, L. H. Seidl. Reprints of *Ocean Engrg. II Conf.*, Univ. of Delaware, Newark, Del., June 9-12, 1975.
Physical and Mathematical Modeling on Dynamic Responses of Supertankers Moored at Seaberth Subjected to Wave Action, T. T. Lee, Volume 1 (text, appendices A, B, C; 127 pp.) and Volume 2 (Appendix D; 299 pp.); unpublished manuscripts.
Drift Forces on Moored Vessels of Minimum Draft Clearance, A. J. James, *Master of Science Paper*, Dept. of Ocean Engrg., Univ. of Hawaii, May 4, 1976; 54 pages.

054-09280-420-52

OPERATIONAL SEA STATE AND DESIGN WAVE CRITERIA FOR OCEAN THERMAL ENERGY CONVERSION PROJECTS

(*b*) Energy Research and Development Administration (ERDA).
(*c*) Prof. Charles L. Bretschneider.
(*d*) Office investigation, i.e., literature review and compilation: also numerical prediction.
(*e*) Identify and evaluate sources of information on wind, wave and current pertinent to the design and operation of an OTEC power plant off coast of USA including Hawaii but not Alaska and in a 40 degree wide belt centered on the Equator; predict these excitations for few particular locations.
(*g*) About one-hundred-sixty sources of information have been identified and published ranging from professional papers through periodicals, charts and atlases to books, especially "Ocean Wave Statistics," 1966 National Physical Lab in England and "Summary of Synoptic Meteorological Observations," 1973-75 of U.S. Naval Weather Service. There is much better information in areas offshore USA–excluding Hawaii–and the Arabian-MidIndian-Bengal-South China Sea area than in Equator-to-south-20 degree area where deficiencies are notable. More hindcasts are recommended for most areas especially those where hurricanes or typhoons are likely and where a dominant current exists. Examples have been published of application of state-of-the-art for predicting deep ocean currents and winds and the waves that they generate including extremes. Hindcasting for particular areas has begun including off Hawaii, Key West, New Orleans and Puerto Rico.
(*h*) **Operational Sea State and Design Wave Criteria for Ocean Thermal Energy Conversion Projects; Literature Available and Prediction Techniques for,** C. L. Bretschneider, Principal Investigator, and J. M. Cherry, T. K. Pyles, R. E. Rocheleau, B. B. Scott, E. E. Tayame, Graduate Students. *TR-39*, J. K. K. Look Lab., Univ. of Hawaii, Mar. 1977, 520 pages.
Operational Sea State and Design Wave Criteria: State of the Available Data for USA Coast and Equatorial Latitude, C. L. Bretschneider, *Proc. 4th Ocean Thermal Energy Con-*

version Conf., published by Energy Research and Development Administration, Washington, D.C., June 1977.

054-09282-340-54

OCEAN THERMAL ENERGY CONSERVATION TYPE POWER PLANT OFF ISLAND OF HAWAII

(*b*) National Science Foundation; Energy Research and Development Administration; and Department of Planning and Economic Development of State of Hawaii.
(*c*) Karl H. Bathen.
(*d*) Field investigation and numerical modeling; applied research; some of material to be used in Master's thesis.
(*e*) Define physical characteristics of the area in the Pacific Ocean offshore Keahole Point (N19-45 W156-04) on leeward side of the Island of Hawaii as potential site for an OTEC type power plant (likely floating) of 100 to 240 mega-watt capacity. Purpose of the study is to define the oceanographic conditions, and impact on the environment–physical, social and economic–of the OTEC Plant. It is concluded that the area is exceptionally seakindly with a large hot-cold water temperature differential relatively nearshore to a sympathetic population and hence a most promising one for OTEC Plant operation. The study off Keahole Point continues, e.g., thru 1978 it will include in situ observations at 2,000 ft depth of water temperature and salinity and current velocity for the Plant in general, and in particular tests off the Point of the bio-fouling of the heat-exchanger (under Prof. J. G. Fetkovich of Carnegie-Mellon U. and Prof. F. C. Munchmeyer of U. of Hawaii) and numerical prediction of sea and current state and criteria for operation and design of the Plant structure (under Prof. C. L. Bretschneider of U. of Hawaii).
(*h*) **Evaluation of Oceanographic Aspects and Environmental Impact of Nearshore Ocean Thermal Energy Conversion Plants on Sub-Tropical Hawaiian Waters,** published by Center for Engrg. Research; Univ. of Hawaii; K. H. Bathen, et al., NSF-RANN Grant AER-74-17421-A01, Apr. 1975, 130 pages.; K. H. Bathen; period June 75-Oct. 75. *Final Report to Dept. Planning and Economic Development*, State of Hawaii, Nov. 1975, 80 pages; K. H. Bathen, presented *Fall 1975 Mtg. Amer. Geophys. Union*, San Francisco, Nov. 1975, 16 pages.
Oceanographic and Socio-Economic Impact of a Nearshore Ocean Thermal Conversion Power Plant in Hawaii, K. H. Bathen, *LOOK LAB/HAWAII* **5**, 2, pp. 15-32, July 1975.

054-10050-420-44

WAVE ATTENUATION AND WAVE-INDUCED SETUP OVER SHALLOW REEF

(*b*) National Oceanic and Atmospheric Administration; Office of Sea Grant Program; Office of Marine Affairs Coordinator, State of Hawaii.
(*c*) T. T. Lee and F. Gerritsen.
(*d*) Field investigation; experimental and theoretical studies laboratory; applied research and Master's thesis.
(*e*) Improve understanding of the characteristics of water waves from deep ocean which break on a reef and then travel shoreward to runup on and reflect from a beach. The plan during September 77-78 is to complete water level measurements at seven points on 1/4-mile long reef-to-beach course on south shore Oahu (N21-17 W157-52) and in laboratory in 180') 4' wide tank; analyze measurements and refine mathematical model and compare output with that obtained by others; develop formula for predicting pertinent behavior together with graphical solution and predict for specific locations in Hawaii; publish final report.
(*f*) Started September 1975; to be completed August 1978.
(*g*) The typically offshore waves incident on the reef are swell with narrow banded spectrum. These tend to arrive in groups ("sets" in surfer jargon) which then are modulated at a beat frequency. As they shoal on the reef, typically secondary waves are formed indicating a very nonlinear wave process. The waves which reform inside the reef after breaking have multiple crests. Power spectra and cumulative energy spectra have been obtained for each of the seven water level measuring stations on the reef-to-beach ocean course along with percent of total energy isolines vs frequency and distance offshore in graphical form for each day of measurements in the ocean. Wave attenuation primarily is at the expense of the energy at the primary frequency. Nonlinear transfer of energy is evident, both to high frequencies as exhibited by the secondary harmonic, and to low frequencies, as exhibited by the surf beat. Such transfer is extremely important in a description of the dynamics of the waves within the reef-to-beach system. This phenomenon also has been observed in laboratory experiments at 1:12 scale mainly to determine the response functions for the different ocean measuring stations. Laboratory measurements are being analyzed to determine wave energy dissipation due to breaking and bottom friction using both spectral and zero up-crossing procedures in which secondary wave effects are considered; friction coefficient and breaking factor using linear and/or solitary wave theories especially to determine energy losses and evaluate the scale effects in the laboratory experiment (physical model). The formation of solitons will be modeled numerically using a controlled iteration technique to solve the Korteweg and de Vries equation which is inherently divergent and results compared with measurements. $H_s = 3.57\ \sigma + 0.10$ is the best fit between the height of the significant wave and a standard deviation (σ). Other parameters being evaluated include: wave height and set-up distribution versus distance offshore; wave height and wave period relationship effect of local wind on energy spectra; energy losses due to friction and wave breaking; effect of scale on response functions obtained from field and laboratory measurements.
(*h*) **Wave Transformation Across the Coral Reef,** E. B. Thornton, T. T. Lee, K. P. Black. Presented *Fall Ann. Mtg. Amer. Geophys. Union*, San Francisco, Calif., Dec. 6-10, 1976.
Preliminary Finding from Wave Attenuation and Wave Induced Setup Over Shallow Reef Project, T. T. Lee, K. P. Black, *Working Paper 77-1*, J. K. K. Look Lab., Apr. 4, 1977.
Spectral Analysis and Zero Up-Crossing Program–User's Guide, K. P. Black, *Working Paper 77-2*, J. K. K. Look Lab., Mar. 1977.
Characteristics of Waves Reformed Shoreward After Breaking on a Reef; Ocean, Laboratory, and Mathematical Study Of, T. T. Lee, F. Gerritsen, K. P. Black, *TR-40*, J. K. K. Look Lab. (in preparation).

054-10051-490-88

LABORATORY INVESTIGATION ON OCEAN THERMAL ENERGY CONVERSION (OTEC) SYSTEM

(*b*) Hawaii Natural Energy Institute.
(*c*) T. T. Lee.
(*d*) Experimental study in the laboratory and applied research.
(*e*) Assist in the design of an OTEC power plant located perhaps offshore Hawaii. It is planned to investigate the effect of the OTEC system on ambient ocean physical characteristics and also the effects of changes in ambient ocean stratification on OTEC plant efficiency by measurements in a very large and deep circular tank (40 ft high and 30 ft in diameter) at J. K. K. Look Laboratory of the flow-temperature field around the water intake-outlet subsystem. Measurements will be compared with predictions made using a numerical model being developed by Ph.D. candidate.
(*f*) Started September 1975 with August 1978 as estimated completion date.
(*g*) A working model was constructed which demonstrates the principle of operation of an OTEC power plant (it is not suitable for use in the measurement program). Laboratory simulation facilities are under construction. Data acquisition system is being designed.
(*h*) **Oceanographic Engineering Research on Ocean Thermal Energy Conversion for Hawaii,** T. T. Lee, K. H. Bathen. Proposal for Year 1977-78 to Univ. of Hawaii Sea Grant Program dated Feb. 1977.

054-10054-420-00

WAVE-INDUCED INSTABILITY OF CONCRETE CUBES

(*c*) R. A. Grace.
(*d*) Experimental investigation in the ocean of the wave-induced kinematical conditions necessary to initiate motion of concrete cubes of various sizes (1 to 4 1/2 inches) and various specific gravities.
(*e*) Site in 37 feet of water. Blocks set on a concrete slab. Kinematics obtained by a ducted current meter. Observer diver used to signal movement of cubes.
(*f*) Completed.

054-10055-420-00

WAVE FORCES ON SUBMERGED SPHERES

(*c*) R. A. Grace.
(*d*) Experimental, field project on wave-induced forces on a sphere. Maximum-force, drag, and inertia coefficients are derived. Master's paper project.
(*e*) The sphere was 29 inches in diameter, attached to a 5-foot-long cantilever mounted vertically on a ballasted steel base. Strain gages on the cantilever permitted force-measuring. Water depth 37 feet.
(*f*) Completed.
(*g*) Excellent correlation of maximum-force coefficient with adapted Keulegan-Carpenter period parameter.
(*h*) **Inertia and Drag Coefficients for a Submerged Sphere,** G. Zee, *M.S. Plan "B" Paper*, Dept. of Ocean Engrg., Univ. of Hawaii, 60 pages, Dec. 1976.

054-10056-420-60

PRESSURE VARIATIONS UNDER WAVES

(*b*) State of Hawaii, Marine Affairs Coordinator's Office.
(*c*) R. A. Grace.
(*d*) Experimental, field and laboratory investigation of the success of the linear and second-order cnoidal wave theories in predicting surface wave heights from pressure head variations near the bottom.
(*e*) Field study in Hawaii in 37 feet of water. Laboratory study at Oregon State University with depths of 9.5 and 11.5 feet.
(*f*) Data collection completed; report in preparation.

054-11709-420-44

SLANTED LOOK AT OCEAN WAVE FORCES ON PIPES

(*b*) National Sea Grant Program, NOAA; American Gas Association; State of Hawaii.
(*c*) R. A. Grace, Professor of Civil Engineering.
(*d*) Experimental study in the ocean to obtain wave force coefficients for a test pipe, on the sea floor, angled with respect to the wave fronts.
(*e*) Test pipe made of steel, 16 inches in diameter and 17.5 feet long. Forces measured by strain gage beams. Length of instrumented pipe section–40 inches. Pipe mounted on and 1/2 inch above shallow base set on the bottom in 37 feet of water. Base faired in with natural sea floor. Kinematics measured with a ducted current meter and wave conditions obtained from wave pressure records and visual observations of a surface-piercing wave staff. All measuring instruments installed immediately prior to data taking. Data recorded on project boat anchored above test site.
(*f*) Started September 1978; to be completed August 1979.
(*g*) Data processing incomplete. There appears to be little difference between the horizontal and vertical force coefficients obtained herein for a 15° angle between the wave fronts and the pipe orientation and those applicable when the wave fronts and pipe are parallel.

HITTMAN ASSOCIATES, INC., Rocky Mountain Regional Office, Woodside Plaza I, Suite 122, 5500 S. Syracuse Circle, Englewood, Colo. 80111. Michael A. Nawrocki, Manager.

055-10904-870-34

MONITORING AND MODELING OF SHALLOW GROUNDWATER SYSTEMS IN THE POWDER RIVER BASIN

(*b*) U.S. Department of the Interior, Bureau of Mines.
(*c*) Gary E. McIntosh, Technical Project Officer, Department of the Interior, Bureau of Mines, Denver Mining Research Center, Building 20, Denver Federal Center, Denver, Colo. 80225.
(*d*) Theoretical and field investigation; applied research.
(*e*) The primary objective of the study is to assess and predict the overall impact which the surface mining of coal will have on the shallow groundwater and the surface water in the basin. Monitoring of ground and surface water flow and quality is being performed. A finite-difference computer model of the groundwater flow, a groundwater quality model, and a surface water flow and quality model are being developed and linked into an overall hydrologic simulation model of the structural basin.
(*g*) Project began in July 1976. Currently 18 months of monitoring data are available. Groundwater model is operational and is being calibrated and verified. Surface water models are being developed.
(*h*) **Simulation of the Effects of Surface Mining on Groundwater in the Powder River Basin,** G. E. McIntosh, *Soc. Mining Engineers of AIME, Preprint No. 78-F-91*, presented 1978 AIME Annual Meeting, Denver, Colo., Feb. 28-Mar. 2, 1978, 11 pp.
Evaluation of Shallow-Aquifer Disturbance by Strip Mining, M. A. Nawrocki, presented ASCE Natl. Spring Convention, Pittsburgh, Pa., Apr. 24-28, 1978.

HOWARD UNIVERSITY, Department of Civil Engineering, Washington, D.C. 20059. Dr. I. W. Jones, Department Chairman.

056-10905-300-00

REGIME SENSITIVITY TO FLOW AND GEOMETRIC VARIABLES

(*c*) Dr. S. C. Mehrotra, Visiting Assoc. Professor of Civil Engineering.
(*d*) Theoretical, basic research; Master's thesis.
(*e*) Regime sensitivity to variations in discharge and channel dimensions is studied for circular and trapezoidal channels on theoretical and dimensional bases.
(*f*) Completed.

056-10906-200-00

ON HYDRAULIC EXPONENTS

(*c*) Dr. S. C. Mehrotra, Visiting Assoc. Professor of Civil Engineering.
(*d*) Theoretical, basic research; Master's thesis.
(*e*) The hydraulic exponents of uniform and critical flow computations have been investigated analytically taking their variation with flow depth into account. The results differ considerably from classical text-book results in which the depth variation of these exponents is ignored. Trapezoidal geometry only has been considered.

056-10907-810-00

ON SOME OVERLAND FLOW PARAMETERS

(*c*) Dr. S. C. Mehrotra, Visiting Assoc. Professor of Civil Engineering.
(*d*) Theoretical, basic research; Master's thesis.
(*e*) The time of concentration of overland flow is examined with special emphasis to the unsteady phase of the overland flow. The time to reach a steady state for the overland flow regime is also examined and compared to the time of concentration for a uniform rainfall excess of indefinite duration.

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UNIVERSITY OF IDAHO, College of Engineering, Moscow, Idaho 83843. M. L. Jackson, Acting Dean.

057-09848-880-33

INTERACTING EFFECTS OF MINIMUM FLOW AND FLUCTUATING SHORELINES ON BENTHIC STREAM INSECTS

(*b*) Office of Water Resources Research, Department of Interior.
(*c*) E. Woody Trihey, Assistant Director, Idaho Water Resources Research Institute.
(*d*) Field investigation operation.
(*e*) Insect communities from both deep and shallow water areas were investigated for the purpose of providing community analysis of the lower mainstream of the Clearwater River and determine the effort of fluctuating power releases from Dworshak Dam upstream and backwater effect of the Lower Granite Dam pool downstream.
(*f*) Completed.
(*g*) Data on insect populations are available. Fluctuating power releases do not appear to have an adverse effect on insect population, where the Lower Granite Pool has a profound effect on populations.
(*h*) **Interacting Effects of Minimum Flow and Fluctuating Shorelines on Benthic Stream Insects,** M. A. Brusven, E. F. Trihey. *Research Technical Completion Report*, Project A-052-IDA, Idaho Water Resources Research Inst., Univ. of Idaho, 1978.

057-09850-840-82

APPLICATION OF AGRICULTURAL CHEMICALS THROUGH IRRIGATION SYSTEMS

(*b*) Idaho Potato Commission, Diamond Shamrock Chemical Company, Idaho Agricultural Experiment Station.
(*c*) Galen McMaser, Professor, Agricultural Engineering.
(*d*) Field investigation; development, M.S. thesis.
(*e*) A study of mixing, dilution and uniformity of application of agricultural chemicals injected into irrigation systems. A comparison with other methods of application has been made.
(*g*) The process of sprinkler application compares very well with ground-rig application and shows less problems with toxicity on potato plants. Distribution of insecticide is not uniform if injected too close (several feet) to mainline branches.
(*h*) **Herbicides Through Sprinklers,** R. H. Callihan, G. M. McMaster, *Current Information Series No. 369*, Univ. of Idaho College of Agriculture, 1977.
Short-Term Sprinkler Patterns by Dye-Concentration Method, G. M. McMaster, *Paper 77-2566*, 1977 ASAE Winter Meeting, Chicago, Ill.

057-09852-830-61

EROSION RESEARCH FOR NORTHERN IDAHO–MODELING OF RUNOFF FOR EROSION STUDIES

(*b*) Idaho Water Resources Research Institute, Agricultural Research Service and Idaho Agricultural Experiment Station.
(*c*) Myron Molnau, Professor, Agricultural Engineering.
(*d*) Field investigation; applied research, M.S. thesis.
(*e*) Develop and test a computer simulation model for snowmelt and erosion that is applicable to the Palouse region.
(*g*) An erosion simulation model has been developed. This model has been coupled with the USDAHL-74 runoff model adapted for the Palouse region. The simulation is good when little overland flow is present but is poor during periods of high computed overland flow.
(*h*) **Effect of Antecedent Conditions of Frozen Ground Floods,** R. Pedersen, M. Molnau, E. S. Yen, *Research Technical Completion Report*, Idaho Water Resources Research Inst., 1977.

057-09853-840-36

EVALUATION OF PRACTICES AND SYSTEMS FOR IMPROVING THE QUALITY OF IRRIGATION RETURN FLOWS

(*b*) Environmental Protection Agency, Idaho Agricultural Experiment Station.
(*c*) D. W. Fitzsimmons, Professor and Head, Agricultural Engineering.
(*d*) Field investigation; operation, M.S. thesis.
(*e*) Purpose is to determine effectiveness of settling ponds, other tail water control systems and alternative water management practices in reducing nutrient losses and pollution from irrigated fields.
(*g*) Fourteen best management practices have been selected for possible implementation. Eleven sediment ponds, T-slots, retention structures, a pump back system and vegetative buffer strips were in use in 1978. Twenty-four out of twenty-six farmers in a 3000-acre watershed are participating in the project.
(*h*) **Vegetative Buffer Strips for Sediment Retention in Irrigation Runoff,** C. E. Brockway, *Proc. ASCE Irrigation and Drainage Specialty Conf.*, Reno, Nev., 1977.
On-Farm Methods for Controlling Sediment and Nutrient Losses, D. W. Fitzsimmons, et al., *Proc. Natl. Conf. Irrigation Return Flow Quality Management*, Fort Collins, Colo., 1977.
Evaluation of Measures for Controlling Sediment and Nutrient Losses From Irrigated Areas, D. W. Fitzsimmons, et al., *EPA Technical Series*, U.S. Environmental Protection Agency, Ada, Okla., 1978.

057-09855-070-34

SEEPAGE THROUGH PARTIALLY SATURATED SHALE WASTES

(*b*) Bureau of Mines, U.S. Department of Interior.
(*c*) G. L. Bloomsburg, Professor, Agricultural Engineering.
(*d*) Experimental; applied research, M.S. thesis.
(*e*) A computer simulation model for unsaturated flow is used to predict flow through waste shale piles.
(*f*) Completed.
(*g*) The project showed that waste shale has a high moisture holding capacity and therefore it should be possible to design piles that will not allow water to leach residual oil and salts into the ground or surface water systems. The computer program was also used to simulate flow from a tailings pond.
(*h*) **Seepage Through Partially Saturated Shale Wastes,** G. L. Bloomsburg, R. D. Wells, *Final Report on Contract HO-252065*, U.S. Dept. of Interior-Bureau of Mines, Agric. Engrg. Dept., Univ. of Idaho, Moscow, Idaho, 1978.
Moisture Distribution in Processed Shale Profiles Affected by Atmospheric Evaporation and Storms, R. D. Wells, *M.S. Thesis*, Agric. Engrg. Dept., Univ. of Idaho, Moscow, Idaho, 1979.

057-09859-870-82

LARGE, DEEP-TANK TESTS OF FULL-SIZE AERATORS

(*b*) Northwest Pulp and Paper Association.
(*c*) M. L. Jackson, Professor, Chemical Engineering.
(*d*) Experimental; applied research, M.S. thesis.
(*e*) A 75 ft column has been used to demonstrate the deep-tank biological treatment process. The advantage of the deep-tank process is more efficient use of oxygen which is pumped in at the bottom of the column.
(*f*) Completed.
(*g*) The process has implications for fermentations other than those involving wastewater treatment such as for the growth of single cell protein for animal or food use. A second, unique installation of the process is currently being developed for a corrugated box recycle plant in California. Performance for operation at high temperature will be determined. Patent rights have been retained by the University.

(*h*) **Scale-Up and Design for Aeration and Mixing in Deep-Tank Fermentation,** M. L. Jackson, C. C. Shen, *AIChE Journal* **24,** 63, 1978.

Comparison of Nine Aeration Devices in a Tank at a 43-Foot Liquid Depth, M. L. Jackson, G. Hoech, report to Northwest Pulp and Paper Association, 1978.

Continuous Fermentation Process and Apparatus, U.S. Patent No. 4069149, M. L. Jackson, 1978.

057-09861-870-10

PILOT PLANT WORK ON AMMONIA CONTROL: DWORSHAK NATIONAL FISH HATCHERY

(*b*) U.S. Army Corps of Engineers.
(*c*) A. T. Wallace, Professor, Civil Engineering.
(*d*) Experimental; design, M.S. thesis.
(*e*) Evaluate various schemes for water treatment in large fish hatcheries which reuse their rearing water.
(*g*) A pilot plant using a floating media for attachment of nitrifying bacteria has been developed.
(*h*) **Study Handling and Treatment of Dworshak National Fish Hatchery,** A. T. Wallace, G. J. Presol, report to U.S. Army Corps of Engrg., Walla Walla District, Civil Engrg. Dept., Univ. of Idaho, Moscow, Idaho, 1974.

Water Quality in the Clearwater River as Affected by Dworshak National Fish Hatchery Under Varying Conditions of Waste Discharge, A. T. Wallace, report to U.S. Army Corps of Engrs., Walla Walla District, Civil Engrg. Dept., Univ. of Idaho, Moscow, Idaho, 1975.

057-09863-110-54

LASER VELOCIMETER STUDIES OF MHD ENTRANCE FLOWS

(*b*) National Science Foundation.
(*c*) W. J. Thomson, Professor, Chemical Engineering.
(*d*) Experimental; applied research, Ph.D. dissertation.
(*e*) A theoretical/experimental study of the influence of a strong magnetic field on the fluid mechanic behavior of electrically conducting fluid. The studies include measurements of point velocities during both laminar and turbulent flow with a split beam, laser Doppler velocimeter.
(*f*) Completed.
(*g*) Results are given in the following dissertation.
(*h*) **Laser-Doppler Velocimeter Studies of MHD Entrance Flows,** A. Hama, *Ph.D. Dissertation*, Chemical Engrg. Dept., Univ. of Idaho, Moscow, Idaho, 1978.

Developing Velocity Profiles in an MHD Duct, W. J. Thomson, *Physics of Fluids*, Sept. 1973.

057-09864-140-52

HEAT TRANSFER IN FLUIDIZED BEDS

(*b*) ERDA.
(*c*) W. J. Thomson, Professor, Chemical Engineering.
(*d*) Experimental; applied research, M.S. thesis.
(*e*) Direct comparisons of the heat transfer rates from immersed tubes to various sized fluidized beds equipped with different distribution plates and two sizes of particulates are being conducted.
(*f*) Completed.
(*g*) Results of this work may be used in various processes where heat transfer in fluidized beds is being used.
(*h*) **Bubble Behavior Around Tubes Immersed in Fluidized Beds,** W. J. Thomson, *AIChE Symp. Series No. 128*, *69*, 68, 1973.

Fluidized Bed Heat Transfer–The Packet Theory Revisited, *CEP Symposium Series 73*, 1977.

A Comparison of "In Bed' Heat Transfer for Two-Dimensional and Three-Dimensional Fluidized Beds, R. D. Teichmer, *M.S. Thesis*, Chemical Engrg. Dept., Univ. of Idaho, Moscow, Idaho, 1977.

057-10899-840-31

IRRIGATION WATER MANAGEMENT

(*b*) Idaho Water Resources Research Institute, Bureau of Reclamation and Idaho Office of Energy.
(*c*) J. R. Busch, Assoc. Professor, Agricultural Engineering.
(*d*) Field investigation; operation, M.S. and Ph.D. thesis.
(*e*) This project is made up of a series of sub-projects which include the following objectives: To develop and apply techniques for determining designs and management plans for large scale irrigation systems. To obtain water cost information for a wide range of irrigation districts in the Snake River Basin. To study relationships between water-use efficiencies to define factors that will provide improved water management. To evaluate and test irrigation system components for energy conservation. To apply operational models to groundwater systems for evaluation of hydrologic impacts due to irrigation development and changes in land use.
(*g*) Irrigation application systems have been evaluated to determine the effects of system design and management criteria on the level of water management. Relationships between water costs and efficiencies are being developed. Data on irrigation pumping demand have been analyzed to determine load patterns and the effects of various load management schemes on energy use.
(*h*) **Optimizing Irrigation System Design,** G. D. Galinato, J. R. Busch, C. E. Brockway, *Research Technical Completion Report to Bureau of Reclamation*, Agricultural Engrg. Dept., Univ. of Idaho, Moscow, Idaho, 1977.

Rapidly Obtaining Optimal Irrigation System Designs, J. R. Busch, G. D. Galinato, C. E. Brockway, G. E. Steinbach, *Paper 78-2009* presented at 1978 ASAE Summer Mtg., Logan, Utah, 1978.

Optimal Irrigation Management Strategy Under Hydrologic and Irrigation Efficiency Uncertainty Regimes, C. M. Udeh, *Ph.D. Dissertation*, Agricultural Engrg. Dept., Univ. of Idaho, Moscow, Idaho, 1978.

Planning Optimal Irrigation Distribution and Application Systems: Teton Flood Damaged Lands, R. G. Allen, C. E. Brockway, J. R. Busch, *Final Report to SEA-FR Kimberly, Idaho*, Agricultural Engrg. Dept., Univ. of Idaho, Moscow, Idaho, 1978.

057-10908-810-05

RUNOFF CHARACTERISTICS OF GRAZED AND UNGRAZED WATERSHEDS IN THE NORTHWEST

(*b*) SEA-FR, Pullman, Washington.
(*c*) M. P. Molnau, Professor, Agricultural Engineering.
(*d*) Field investigation, applied research, M.S. and Ph.D. thesis.
(*e*) The project is to evaluate rainfall-runoff characteristics of the representative Northwest cattle-grazed watershed in relation to climate, topography, soil and vegetative, develop an applicable watershed model and compare these to the same parameters on an ungrazed area.
(*g*) Precipitation and runoff data have been collected.

057-10909-830-05

EROSION CONTROL IN THE PALOUSE REGION

(*b*) SEA-FR, Pullman, Washington, Idaho Department of Health and Welfare, and Lata Soil Conservation District.
(*c*) M. P. Molnau, Professor, Agricultural Engineering.
(*d*) Field investigation, applied research, M.S. thesis.
(*e*) The project is to measure field erosion losses, evaluate present watershed runoff and erosion models and evaluate conservation practices.
(*g*) Field data are being collected.
(*h*) **Integration of Remotely Sensed Data with Soils and Slope Maps for Erosion Hazard Predictions,** W. J. Ripple, *M.S. Thesis* (*Geography*), Univ. of Idaho, Moscow, Idaho, 1977.

057-10910-880-33

EFFECTS OF REDUCED STREAM DISCHARGE ON FISH AND AQUATIC MACROINVERTEBRATE POPULATIONS

(*b*) OWRT.
(*c*) R. G. White, Asst. Professor, College of Forestry and J. H. Milligan, Assoc. Professor, College of Engineering.
(*d*) Field investigation, applied research, M.S. thesis.
(*e*) This study is to quantify the relationship between discharge and fish biomass and numbers as influenced by channel configuration and components of the habitat. Controlled tests will be conducted in two large flumes on the Grande Rhonde River in Oregon.
(*g*) A progress report will soon be available.

057-10911-340-52

A RESOURCE SURVEY OF LOW-HEAD HYDROELECTRIC POTENTIAL-PACIFIC NORTHWEST REGION

(*b*) DOE and OWRT.
(*c*) C. C. Warnick, Professor, Idaho Water Resources Research Institue.
(*d*) Field investigation, applied research, M.S. and Ph.D. thesis.
(*e*) The project is investigating the entire Columbia River Basin in the United States and the remaining portions of Idaho, Oregon and Washington for their low-head hydroelectric production potential.
(*g*) The project is nearly completed. A low-head hydroelectric technology seminar was held in 1978 which attracted wide interest.

057-10912-880-33

USE OF INVERTEBRATE INDICATORS FOR ECOLOGICAL RESILIENCY EVALUATION OF A FLOW REGULATED RIVER

(*b*) OWRT.
(*c*) D. F. Haber, Professor, Civil Engineering.
(*d*) Field investigation, applied research, M.S. thesis.
(*e*) This project addresses ecological resilience as the basis for planning, outlines previous attempts to measure system resilience, and will use a method by which system resilience can be conceptualized and tested in a practical way under field conditions.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN, Colleges of Agriculture and Engineering, Department of Agricultural Engineering, Urbana, Ill. 61801. Roger R. Yoerger, Department Chairman.

058-08024-820-07

NITROGEN AS AN ENVIRONMENTAL QUALITY FACTOR-DETERMINING AND MODELING THE VARIOUS STEPS OF THE N CYCLE

(*b*) U.S. Department of Agriculture; Illinois Institute for Environmental Quality; U.S.-E.P.A.
(*c*) Walter D. Lembke, Professor, Agricultural Engineering Department.
(*d*) Experimental, field investigation, applied research.
(*e*) To determine and model, by using field and analytical procedures, the accuracy with which the amounts of nitrogen can be predicted in various steps of the nitrogen cycle.
(*g*) Nitrogen movement in a soil profile is being studied under a corn crop with three different fertilizers: municipal sludge, animal manure and chemical fertilizer. Rates of movement of nitrogen through the soil profile were found to occur at a greater rate over a shorter time span for chemical fertilizer and at a slower rate over a longer time span for organic fertilizers. This study is being conducted in cooperation with the University of Illinois Agronomy and Horticulture Departments in Mason County, Ill.
(*h*) **Design of Vegetative Filters for Feedlot Runoff Treatment in Humid Areas,** D. H. Vanderholm, and Dickey, *ASAE Paper No. 78-2570*, 1978.

058-08681-810-07

RUNOFF FROM SMALL AGRICULTURAL AREAS IN ILLINOIS.

(*b*) U.S. Department of Agriculture.
(*c*) Dr. J. Kent Mitchell, Assoc. Professor, Agricultural Engineering.
(*d*) Experimental, applied research.
(*e*) Determine the frequencies of peak rates and volumes of runoff from Agricultural Watersheds of 25 to 1000 acres located on permeable soils with mild slopes in Central Illinois. To test and evaluate the usefulness of mathematical hydrologic models to small agricultural watersheds with mild topography. To provide benchmark watersheds in central Illinois for the study of the quality of runoff water.
(*g*) The rainfall and runoff data through 1977 from the Allerton watersheds have been reduced, tabulated and assembled for analysis. A study was completed that evaluated the applicability of hydrologic models described by Huggins and the Soil Conservation Service to small watersheds by comparing the simulated and actual hydrograph for both gaged and ungaged situations. The annual maximum rainfall events plus storms exceeding 2.5 inches from 25 years of rainfall and runoff data from two small watersheds were selected for the model evaluations. One-half of the selected storms were used to calibrate the models. The test storms were simulated only once in order to imitate an ungaged situation. In general, both the Huggin's and SCS model performed similarly on the test storms, but the level of model performance was lower than that for the calibration storms. For both models, the two-day antecedent rainfall was more important in determining antecedent moisture and modifying tabulated curve numbers than was the five-day antecedent rainfall. The time of cencentration which resulted in good hydrograph simulations was about three times larger than that estimated using published empirical relationships. Data from 650 runoff events from 190 recorder-years of record from the four Allerton watersheds and 11 additional watersheds in east central Illinois were used in a study that tested the suitability of four peak runoff models to small agricultural watersheds of mild topography. The SCS model was found to be most satisfactory for the conditions examined.
(*h*) **Hydraulic Frequency Study and Analysis for Allerton Agricultural Watersheds,** S. Hardjoamidjojo. Unpublished *M.S. Thesis*, Library, Univ. of Ill. at Urbana-Champaign.
The Application of Hydrologic Models to Small Watersheds Having Mild Topography, E. C. Dickey, *Ph.D. Thesis*, Library, Univ. Ill., Urbana, 193 p., 1978.
Evaluation of Peak Runoff Models, S. Mostaghimi, *M.S. Thesis*, Library, Univ. Ill., Urbana, 134 p., 1978.

058-08682-820-00

HYDRAULIC AND HYDROLOGIC MODELS OF COMPONENTS OF SOIL AND WATER CONTROL SYSTEMS

(*b*) U.S. Department of Agriculture.
(*c*) Walker D. Lembke, Professor, Agricultural Engineering Department.
(*d*) Theoretical and field investigation; applied research.
(*e*) Develop and use mathematical, electrical, hydraulic and hydrologic models to evaluate the performance of soil and water control systems in Illinois.
(*g*) A study of soil crusting involved the emergence of soybean plants through a crust formed by the application of simulated rainfall. Soil texture, organic matter, rainfall intensity and rainfall energy are the independent variables controlled in this study. Data analysis are being completed. A laboratory study was completed that defined the change with time of soil aggregate and particle size distributions of eroded soil during rainfall events. The clay particle percentage of the eroded material was greater than the clay percentage of the original soil at the beginning of a rainfall event. However, as the event continued, the clay percent-

age approached that of the original soil. The 1977 and 1978 yields from the cooperative investigation of irrigation and drainage on claypan soils by the Agricultural Engineering and Agronomy Departments averaged 7.1 tonnes/ha. for the irrigated plots and 3.3 tonnes/ha. for nonirrigated. Irrigation treatments are sprinkler, furrow and no irrigation. Drainage treatments are surface, subsurface, surface plus subsurface and no drainage. A study was also completed on the hydraulic characteristics of deflected corrugated plastic drain tubing. Laboratory measurements of the hydraulic capacity of tubing deflected with a parallel plate device were found to be in good agreement with hydraulic capacity predictions based on Mannings equation using an ellipse approximation to the cross-sectional shape of the tubing.

(*h*) **Micro-Relief Surface Depression Storage: Changes During Rainfall Events and Their Application to Rainfall-Runoff Models,** J. K. Mitchell, B. A. Jones, Jr., *Water Resources Bulletin 14:777-802*, 1978.

Particle and Aggregate Size Distributions of Eroded Soil, M. C. Pond, *M.S. Thesis*, Library, Univ. Ill., Urbana, 89 p., 1978.

Flow Patterns and Sedimentation in Livestock Oxidation Ditches, J. K. Mitchell, D. L. Day, *Trans. ASAE* **19**, 119-122, 1976.

The Effects of Manure Application on Runoff, Erosion and Nitrate Losses, J. K. Mitchell, R. W. Gunther, *Trans. ASAE* **19**, 1104-1106, 1976.

058-10913-210-82

CPTA/PLASTIC DRAIN TUBING

(*b*) Corrugated Plastic Tubing Association.
(*c*) P. N. Walker, Asst. Professor, Agricultural Engineering Department.
(*d*) Field investigation and applied research.
(*e*) Determine the structural characteristics of deflected plastic drain tubing.
(*g*) Thirty-six samples of 152 mm diameter corrugated plastic tubing, each four meters long, were permanently deflected 0, 10, 20, and 30 percent using a parallel plate device. These samples were then installed in the field at depths of 0.30, 0.45 and 0.60 m to the top of the tubing. These tubing samples were then subjected to repeated loadings by running a combine perpendicularly across the buried samples. Tubing deflection was measured before and after loading. Preliminary results appear to confirm the theory that in relaxed soil tubing with more permanent deflection is less resistant to additional deflection.
(*h*) **Hydraulic Characteristics of Deflected Corrugated Plastic Drain Tubing,** C. L. Armstrong, unpublished *M.S. Thesis*, Univ. Ill., Urbana, 79 p., 1978.

058-10914-870-05

HOME SEWAGE SYSTEMS FOR AREAS WITH SOILS UNSUITABLE FOR SUBSURFACE SEEPAGE FIELDS

(*b*) U.S.D.A.
(*c*) D. H. Vanderholm, Assoc. Professor, Agricultural Engineering.
(*d*) Field investigation, design.
(*e*) The general objective is to accumulate information that will provide a basis for developing and evaluating alternative house sewage treatment systems suitable for use where conventional septic tank seepage fields will not work due to unsatisfactory soil conditions.
(*g*) Preliminary results from the recirculating sand filter indicate excellent quality effluent suitable for discharge from both of the sands under test. Effluent from the aerobic plants, although of fairly good quality, does not meet current criteria for discharge to surface waters. However, since the effluent is completely infiltrated into the soil in adjacent forested area, no water pollution hazard is created.
(*h*) **Home Sewage Systems for Soils Unsuitable for Subsurface Seepage Fields,** D. H. Vanderholm, W. D. Lembke, D. L. Day, *Ill. Agr. Exp. St. DSAC* **6**, pp. 6-8, 1978.

Home Sewage Systems for Soils Unsuitable for Subsurface Seepage Fields, D. H. Vanderholm, W. D. Lembke, D. L. Day, *Ill. Agr. Exp. Sta. DSAC* **5**, pp. 3-6, 1977.

Design Construction and Costs of Recirculating Sand Filters, D. Ralph, D. H. Vanderholm, *Proc. 1978 Ill. Private Home Sewage Disposal Symp.*, Champaign, Ill., Feb. 13-15, 1978.

Design, Construction and Costs of Recirculating Sand Filters, D. Ralph, D. H. Vanderholm, *Proc. Ill. Private Sewage Disposal Symp.*, Agr. Engr. Dept., Univ. of Ill. at Urbana-Champaign, 37-51, 1978.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN, Department of Chemical Engineering, Urbana, Ill. 61801. Professor Thomas J. Hanratty.

059-08683-020-20

STRUCTURE OF TURBULENCE CLOSE TO A WALL

(*b*) Office of Naval Research.
(*d*) Experimental and theoretical; basic research; Ph.D. theses.
(*e*) Electrochemical techniques are used to measure turbulence simultaneously at multiple points. Conditional sampling techniques are used to discern repetitive occurrences. The system is an 8 inch pipe.
(*g*) Eddy structures responsible for the transfer of momentum to a wall have been identified. A regular eddy model appears to give results consistent with many presently available measurements.
(*h*) **Interpretation of the Turbulent Flow in the Viscous Wall Region as a Drive Flow,** D. T. Hatziavramidix, T. J. Hanratty, *Report 1, ONR,* Project Number NR 062-558, Jan. 1978.

059-08685-000-54

FLOW OVER SOLID WAVES

(*b*) National Science Foundation.
(*d*) Experimental; basic research; Ph.D. theses.
(*e*) Models for turbulent flow over waves are being developed. These are being tested by making measurements of the variation of the wall shear stress along the wave surface and of the turbulent energy close to a surface. For large amplitudes waves separation occurs. The separated region is being studied using laser-Doppler techniques.
(*g*) For very small amplitude waves linear theory is applicable. An eddy viscosity concept does a reasonable job in modelling the wave induced variation of the Reynolds stress. The influence of increasing wave amplitudes has been explored.
(*h*) **Influence of the Amplitude of a Solid Wavy Wall on a Turbulent Flow. Part I. Non-Separated Flows,** D. P. Zilker, T. J. Hanratty, *J. Fluid Mech.* **82**, 29 (1977).

A Comparison of Linear Theory With Measurements of the Variation of Shear Stress Along a Solid Wave, C. B. Thorsness, P. E. Morrisroe, T. J. Hanratty, *Chem. Eng. Sci.* **33**, 579 (1978).

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN, Hydrosystems Laboratory, Department of Civil Engineering, Urbana, Ill. 61801. Professor V. T. Chow.

061-07339-810-33

STOCHASTIC ANALYSIS OF HYDROLOGIC SYSTEMS

(*b*) Office of Water Resources Research.
(*c*) Professor V. T. Chow.
(*d*) Theoretical; applied research.
(*e*) Develop a practical procedure by which the stochastic behavior of a hydrologic system can be adequately simulated. In the study a watershed is treated as the stochastic hydrologic system whose components are simulated by

time series models. Emphasis is given to application of the procedure to the planning of rural and urban watersheds in Illinois.

(*h*) **Analysis of Residual Hydrologic Stochastic Processes,** S. J. Karcliotis, V. T. Chow, *J. Hydrology* **15**, 2, Feb. 1972, pp. 113-130.

Theory of Stochastic Modeling of Watershed Systems, V. T. Chow, T. Prasad, *J. Hydrology* **15**, 4, Apr. 1972, pp. 261-284.

Analysis of Multiple-Input Stochastic Hydrologic Systems, *Res. Rept. No. 67*, Water Resources Center, Univ. Ill. at Urbana-Champaign, Urbana, Ill., July 1973, 66 pages.

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061-07340-310-00

CRITERIA FOR HYDROLOGIC DESIGN

(*b*) University of Illinois and Kanazawa University.
(*c*) Professor V. T Chow.
(*d*) Theoretical; applied research.
(*e*) Hydrologic extremes such as floods and low flows are treated as independent random variables. Accordingly, probabilistic models are derived for two approaches of adopting hydrologic extremes as design criteria in water resources project planning. One approach is to use the hydrologic event of a given recurrence interval, and the other is to use the extreme event observed in the record. The models are verified agreeably by the flood data of ten Illinois rivers. Both models give essentially the same results when the period of design is less than one-tenth of the recurrence interval and the length of record. Also, by the Monte Carlo method, synthetic hydrologic extremes are generated by a time-series model for use in water resources systems analysis.
(*h*) **Design Criteria for Hydrologic Extremes,** V. T. Chow, N. Takase, *J. Hyd. Div., Proc. ASCE* **103**, HY4, pp. 425-436, Apr. 1977.

061-08711-810-54

HYDRODYNAMIC MODELING OF FLOOD FLOWS

(*b*) National Science Foundation.
(*c*) Professors V. T. Chow and B. C. Yen.
(*d*) Experimental and analytical.
(*e*) To develop an advanced hydrodynamic model for analysis of flood flows from watersheds. Auxiliary objectives include verification of the developed model by field data and the assessment of relative merits of the nonlinear kinematic wave approximation of flood routing. The model, called system hydrodynamic routing (SHR) model, has been successfully developed and is divided into two parts: overland flow routing and channel network routing. In each part two options are possible, namely, dynamic wave routing and kinematic wave approximation. In the dynamic wave routing, the St. Venant equations are expressed in a gravity-oriented coordinate system and in terms of discharge and flow areas. These equations are used for the convenience of accepting field data and minimizing possible errors in the data. The model is a hydrodynamically advanced flood simulation model with high accuracy and flexibility to help understand the phenomena of floods and is to be used as a measure for evaluation of simpler flood routing methods and for important projects that require high accuracy.
(*h*) **A Laboratory Watershed Experimentation System,** V. T. Chow, B. C. Yen, Civil Engrg. Studies, *Hydraulic Engrg. Ser. No. 27*, Univ. Ill., Aug. 1974, 200 pages.

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Formulation of Mathematical Watershed-Flow Model, C. L. Chen, V. T. Chow, *Trans. ASCE* **137**, pp. 267-268, 1972.

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Hydrodynamic Modeling of Two-Dimensional Watershed Flow, *J. Hydraul. Div., ASCE* **99**, HY11, pp. 2023-2040, Nov. 1973.

A Constant Discharge Siphon for Flow Measurement and Control, B. C. Yen, V. T. Chow, *Proc. Koblenz Symp.* **1**, W. Germany, UNESCO-WMO-IASH, pp. 444-452, 1973.

Role of WES in the Development of Hydrodynamic Watershed Models, V. T. Chow, Intl. Assoc. of Hydrological Sciences, *IAHS-AISH Publication No. 101*, pp. 775-783, 1974.

061-11499-870-36

EVALUATION OF URBAN STORM RUNOFF

(*b*) U.S. Environmental Protection Agency.
(*c*) Professors V. T. Chow and B. C. Yen.
(*d*) Analytical, applied research.
(*e*) This investigation's aim is (1) to develop a method of depth-duration-frequency analysis for precipitation events having short return period (high frequency) for urban storm water runoff management and control purposes, and runoff prediction methods. The eight methods evaluated are the rational method, unit hydrograph method, Chicago hydrograph method, British Transport and Road Research Laboratory method, University of Cincinnati urban runoff method, Dorsch hydrograph volume method, EPA storm water management model, and Illinois urban storm runoff method. The comparison and evaluation are done by using four recorded hyetographs of the Oakdale Avenue drainage basin in Chicago to produce the predicted hydrographs by the methods, and the results are compared with recorded hydrographs.

061-11500-870-36

STORMWATER RUNOFF ON URBAN AREAS OF STEEP SLOPE

(*b*) U.S. Environmental Protection Agency.
(*c*) Professors V. T. Chow and B. C. Yen.
(*d*) Analytical, applied research.
(*e*) Research is being conducted to investigate the applicability of commonly used urban storm runoff prediction models to drainage basins with steep slopes. The hydraulics of runoff on steep-slope areas is first reviewed and its difference from that for mild-slope areas is discussed. Next the difficulties in applying commonly used methods to steep-slope basins are explored. It appears that most engineers are not aware of the problems associated with runoff from steep-slope areas and they do not realize that the numerical results given by the conventionally used methods, if obtainable, may not be reliable. A simple approximate method specifically for steep-slope basins is proposed and an example is provided. The example utilizes the data from the Baker Street drainage basin in San Francisco.

(*h*) **Stormwater Runoff on Urban Areas of Steep Slope,** B. C. Yen, V. T. Chow, A. O. Akan, *Environmental Protection Technology Series EPA-600/2-77-168*, Municipal Environmental Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio, pp. 92, Sept. 1977.

061-11501-810-47

FEASIBILITY STUDY ON RESEARCH OF LOCAL DESIGN STORMS

(*b*) Federal Highway Administration.
(*c*) Professors V. T. Chow, B. C. Yen, and Mr. T. A. Ula.
(*d*) Analytical, applied research.
(*e*) The main objective of this project is to investigate the feasibility of a comprehensive study on nationwide determination of the local design rainstorm hyetographs for urban highway storm drainage facilities. Moments of the statistical values of recorded rainstorms are computed and nondimensional triangular hyetographs are established which can be used for storm drainage design.
(*h*) **Feasibility Study on Research of Local Design Storms,** B. C. Yen, V. T. Chow, *Report No. FHWA-RD-78-65*. Washington, D.C.: Federal Highway Administration, Office of Research and Development, 270 pp., 1977.

061-11502-810-33

MONTHLY STREAMFLOW GENERATION WITH EMPHASIS ON PARAMETER UNCERTAINTIES

(*b*) University of Illinois; Office of Water Resources Research.
(*c*) Professor V. T. Chow and Mr. T. A. Ula.
(*d*) Theoretical applied research.
(*e*) This study is to consider a realistic approach to generate streamflows that will recognize and account for the sampling errors inherent in the estimates of model parameters. Two versions of a linear model of generation are considered. One is the conventional case in which errors are assumed to be uncorrelated; the other is a more general case in which errors are assumed to be generated by a stationary Markov process. The two cases are compared through an application in order to assess any significant changes in the generated streamflows. In the study, the algorithms for the two cases are developed for generation of monthly streamflow sequences. Such generated streamflows are useful as input to the planning and design of water resources systems.

061-11503-870-00

HYDROLOGIC MODELING FOR URBAN DRAINAGE DESIGN

(*b*) University of Illinois.
(*c*) Professor V. T. Chow and Mr. C. D. Morris.
(*d*) Theoretical, applied research.
(*e*) A stochastic hydrologic stimulation methodology is developed for the generation of small time-interval precipitation. This methodology consists of three major components: a probabilistic wet and dry sequence component, a Markovian precipitation distribution component, and a regressive spatial distribution component. This methodology is demonstrated by application to an actual urban rain gauge network, the Boneyard Creek network, consisting of six rain gauges with 12 years of continuous, simultaneous precipitation data. Using this methodology, the model's parameters are evaluated using the 12 years of data; then 100 years of data are generated by the model for both the primary gauge as well as the secondary gauge.

061-11504-810-00

STOCHASTIC ANALYSIS OF WATERSHED FLOW

(*b*) University of Illinois.
(*c*) Professor V. T. Chow
(*d*) Theoretical, applied research.
(*e*) This study is to synthesize the various hydrologic models that have been developed under the direction of the principal investigator on the stochastic analysis of watershed flow in order to present the results of previous researches in a form useful to the academic as well as professional users. The models are classified into three main types: the pseudo-stochastic model of storm rainfall-and-runoff relationship, the stochastic model of annual flows by correlogram and power-spectrum analyses, and the stochastic model of annual flows by transitional probability matrices.
(*h*) **Stochastic Modeling of Watershed Systems,** V. T. Chow, *Advances in Hydroscience* **11**, pp. 1-93, 1978.
Evolution of Stochastic Hydrology, V. T. Chow, *Applications of Kalman Filter to Hydrology, Hydraulics and Water Resources: Proc. AGU Chapman Conf.*, Pittsburgh, Pa., Univ. of Pittsburgh, pp. 13-28, 1978.
Risk and Reliability Analysis Applied to Water Resources in Practice, V. T. Chow, *Proc. Intl. Symp. Risk and Reliability in Water Resources*, Waterloo, Canada, Univ. of Waterloo, pp. 1-13, 1978.

061-11505-810-00

ANALYSIS OF HYDROLOGIC MODELS IN SEMIARID REGIONS HAVING INSUFFICIENT DATA

(*b*) University of Illinois; University of Azarabadegan, Iran.
(*c*) Professors V. T. Chow and A. A. Movahed-Danesh.
(*d*) Analytical, applied research.
(*e*) There are many semiarid regions in the world where hydrologic data are insufficient for developing adequate models for analysis and planning of water resources projects. This study involves the development of correlation between short-term and long-term hydrologic records, thus extending the insufficient data for use in hydrologic modeling. The model being used is of the water-balance type. For application, the data correlation and hydrologic basin modeling are applied to the Rezaieh (Urmia) Lake in Iran, which has a basin area of 43,752 km^2 and an average lake area of 5500 km^2. Because of the unique closed hydrologic system of the lake basin, the wind and lake level data play an important role in the analysis and modeling.

061-11506-870-33

INVESTIGATION OF THE DESIGN STORM CONCEPT IN URBAN WATER RESOURCES PROJECTS–PHASE I

(*b*) Office of Water Research and Technology, AO-095-ILL.
(*c*) Professor H. G. Wenzel, Jr.
(*d*) Analytical, applied research.
(*e*) The design storm is a concept that is commonly used by urban water resources planners and designers. It is selected on the basis of an acceptable probability that one or more system performance parameters will be exceeded. It is assumed that this exceedence probability will be achieved by the system if it is used to select the design storm. This concept violates the basic nonlinear nature of watershed response, and this study is directed at examining the validity of this procedure. Because of a lack of long-term urban rainfall-runoff data, a simulation model will be used to obtain the long-term simulated response of an urban catchment which will have sufficient rainfall-runoff data to permit model calibration. The response of the model simulation will be analyzed statistically and these results compared to a similar analysis of the precipitation input in order to test the assumption that the frequency response of the catchments is the same as the rainfall.

061-11507-200-00

MATHEMATICAL MODELING OF UNSTEADY OPEN-CHANNEL FLOW

(*b*) University of Illinois.
(*c*) Professor B. C. Yen.
(*d*) Theoretical, applied research.
(*e*) Unsteady open-channel flows can be described by the one-dimensional continuity and momentum equations. They can also be approximated by the simplified forms of these equations, e.g., the St. Venant equations, diffusion-wave equations, and kinematic wave equations. Modeling techniques using these equations for flow in channel networks are studied.

(*h*) **A Nonlinear Diffusion-Wave Model for Unsteady Open-Channel Flow,** A. O. Akan, B. C. Yen, *Proc. 17th Congr. Intl. Assoc. Hydraul. Res.,* **A98,** 1-10 (1977).

061-11508-390-00

RELIABILITY-BASED HYDRAULIC AND HYDROLOGIC DESIGN

(*b*) University of Illinois; Office of Water Research and Technology.
(*c*) Professors B. C. Yen and W. H. Tang.
(*d*) Theoretical, applied research.
(*e*) The major purpose of this research is to develop a new method for hydraulic and hydrologic design of engineering projects avoiding the conventionally used and arbitrarily chosen design return period and safety factor. The new method is based on conditional probability theory considering various uncertainties in an engineering project, including uncertainties on rainfall, runoff, and other hydrologic aspects, on formula reliability, channel or pipe roughness, and other hydraulic factors, on structural variables, and on material and construction reliabilities. The method has been applied successfully to storm sewer design.

061-11509-870-33

SURCHARGE OF SEWER SYSTEMS

(*b*) Office of Water Research and Technology, USDI.
(*c*) Professor B. C. Yen and Mr. N. Pansic.
(*d*) Theoretical, applied research.
(*e*) The main objective of this research is to study the effect of sewer surcharge on urban water drainage management. A practical method for reliable simulation of sewer surcharge based on the theories of unsteady open-channel and conduit flows and appropriate boundary conditions will first be developed. The effects of surcharge on different urban drainage operational conditions will then be investigated. The effect of surcharge on optimal sewer system design will also be studied. Examples will be presented and recommendations will be made.

061-11510-870-00

HYDRAULICS OF STORM SEWERS

(*b*) University of Illinois.
(*c*) Professor B. C. Yen.
(*d*) Analytical, applied research.
(*e*) This research covers a broad scope consisting of many aspects of hydraulics related to design and operation of storm sewers. Reliabilities of various routing methods for the unsteady flow in a single sewer as well as sewer networks are investigated, with particular emphasis on the effect of the junctions. The influences of on-line retention, surcharge, and roughness factors are all considered. The results are particularly useful for improvement of sewer designs.
(*h*) **Hydraulics of Storm Sewer Design,** B. C. Yen, *Proc. Intl. Symp. on Urban Hydrol., Hydraul., and Sediment Contr.,* 345-362 (1977).

061-11511-430-54

DYNAMICS OF OCEAN STRUCTURES

(*b*) National Science Foundation, NSF 73-03677.
(*c*) Professor J. P. Murtha and Mr. C. H. Ingrum.
(*d*) Analytical research.
(*e*) The purpose of this research is to develop from experimental data and analytical studies methods for reliable prediction of fluid-structure interaction effects on structures responding dynamically to water waves and earthquakes. Sophisticated analytical methods in the field of structural dynamics, including those assuming the random nature of the sea, have been developed to make response predictions for offshore structures. These methods are based on simplified equations to predict fluid structure to interaction effect. In the present study simple structural dynamic experiments are conducted in the wave tank using regular and irregular (simulated random) waves. Comparison is made between theoretical and experimental responses.

061-11512-870-54

AIR BUBBLE-INDUCED DILUTION

(*b*) National Science Foundation, ENG-76-24226.
(*c*) Professor W. H. C. Maxwell and Mr. S. Tekeli.
(*d*) Analytical, experimental research.
(*e*) The control of water pollution may be achieved by enhancing the mixing, diffusion, and dispersion of chemical and thermal pollutants after pollution has occurred, or by preventing the pollution of water bodies by artificial barriers. Bubble screens appear to have the potential of doing either. They can augment convective heat and mass transfer to induce artificial mixing and to enhance dilution at outfalls, or they can be used as pneumatic barriers against density currents and estuary shoaling. The objectives of this research project are to develop a detailed understanding of the physics of bubble screens, and their interaction with jet-type discharges. The investigation is both experimental and analytic. First, a simple bubble-induced vertical plume is being studied, next the interaction between two crossing momentum jets, and finally the interaction between a vertical bubble-induced plume and a horizontal momentum jet.
(*h*) **Interface Geometry for Two-Layered Stratified Flow,** W. H. C. Maxwell, *J. Hydraul. Div., Proc. ASCE* **103,** HY2, 183-189 (1977).

061-11513-130-00

DATA SAMPLING FOR BUBBLY MIXTURES

(*b*) University of Illinois.
(*c*) Professors W. H. C. Maxwell, V. J. McDonald, and Mr. S. Tekeli.
(*d*) Experimental, analytical research.
(*e*) In the analysis of nonstationary data for time-averaged values of the variables under consideration, when the periodicities are of long duration, the process of data collection becomes prohibitively expensive. A technique, requiring only periodic sampling of the variables over the fundamental period, has been developed to enable estimation of desired information from a fraction of the full record within acceptable limits of accuracy. The technique was tested using laboratory data collected in an oscillating bubbly plume. Temporal variations of fluid velocity were recorded on magnetic tape over long durations and the data analyzed digitally on the computer. The results of sampling were tested against the results of the entire record.

061-11514-050-00

SHALLOW SUBMERGED RECTANGULAR JETS

(*b*) University of Illinois.
(*c*) Professor W. H. C. Maxwell and Mr. M. Demissie.
(*d*) Experimental, analytical research.
(*e*) Momentum diffusion from incompressible nonbuoyant, turbulent, three-dimensional slot jets with deep and shallow submergence is being studied both experimentally and theoretically. In the theoretical analysis, Reichardt's hypothesis for free turbulence is used in the development of the mathematical model. The objective is to describe the mean parameters of flow downstream from three-dimensional slot jets with various aspect ratios. A laboratory investigation continues, in which careful measurements of momentum flux distributions, using direct connection to a computer to determine time-average values, are being collected for slot outlets having different aspect ratios and submergences.

061-11515-050-00

STUDY OF CROSSING CIRCULAR JETS

(*b*) National Science Foundation; University of Illinois.
(*c*) Professor W. H. C. Maxwell and Mr. S-C. A. Chiu.
(*d*) Experimental, analytical research.

(e) This NSF undergraduate research project was a cooperative venture involving a student from Southern Illinois University at Carbondale. The student conducted laboratory experiments at UIUC while on a summer appointment. The study involved the measurement of velocity traverses in two intersecting air jets. The angle of intersection was 90 degrees. Measurements were taken for different discharges of the jets with magnitude and direction of the time-average velocity being recorded. The behavior was studied with each jet operating singly as well as in combination. The results indicate that the resulting flow downstream from the intersection cannot be predicted by either vector addition of velocites or momentum flux densities at each point in the flow field. Reverse flows were observed behind the point of intersection.

061-11516-870-54

TRANSPORT OF EFFLUENTS IN RIVERS

(*b*) National Science Foundation, ENG-76-11220.
(*c*) Professor E. R. Holley, and Messrs. J. B. Stall, Y. H. Tsai, S. W. Verhoff.
(*d*) Theoretical, applied research.
(*e*) Evaluation of potential effects of an effluent discharged or accidentally spilled into a river includes analyzing the effluent transport. Depending on the type of effluent or spill, the necessary predictions can involve analysis of transverse and/or longitudinal mixing. Both processes are being studied analytically and laboratory experiments on longitudinal mixing are being conducted. For transverse mixing, the advective-diffusion equation will be solved taking into account both natural changes in width, depth, and transverse diffusion coefficient for the river and the distance between tributary streams. For longitudinal mixing, the natural stream geometry, including the irregularities in boundary geometry, will be included in a reevaluation of the initial-convective period duration and the longitudinal dispersion coefficient. Results will be compared with available data.
(*h*) **Oxygen Transfer at the Air-Water Interface,** E. R. Holley, *Transport Processes in Lakes and Oceans*, R. J. Gibbs, (ed.), Plenum Press, N.Y., 117-150 (1977).

061-11517-210-33

INJECTION SYSTEMS FOR RAPID MIXING IN PIPE FLOWS

(*b*) Office of Water Research and Technology, 14-34-0001-8015.
(*c*) Professor E. R. Holley and Mr. S. D. Fitzgerald.
(*d*) Theoretical, applied research.
(*e*) This research concerns the problem of obtaining rapid mixing of a miscible fluid injected into a pipe flow without having mixing devices or other apurtenances mounted inside the pipe. Laboratory experiments will be conducted to determine the mixing induced by several injection systems. Specifically, attention will be directed toward jet-type injection with the ports at the pipe wall and with the jets directed counter to and across the ambient flow. For steady, uniform pipe flow, the mixing characteristics and injection power requirements will be determined for various numbers, orientations, and initial momentum of the injection jets. Injection systems providing the most rapid mixing will be identified and the degree of mixing which can be obtained with the injection will be defined.
(*h*) **Dilution Method of Discharge Measurement in Pipes,** E. R. Holley, *Proc. National Bureau of Standards Flow Measurement Symp.*, NBS Spec. Publ. **484**, 385-421 (1977).

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN, College of Engineering, Department of Mechanical and Industrial Engineering, Urbana, Ill. 61801. Professor B. T. Chao, Department Head.

062-10915-040-14

APPLICATION OF THE HODOGRAPH EQUATION TO POTENTIAL FLOWS

(*b*) U.S. Army Research Office.
(*c*) W. L. Chow, Professor of Mechanical Engineering.
(*d*) Theoretical, basic and applied research, Doctoral thesis.
(*e*) The usefulness of the hodograph transformation will be explored through numerical calculations of hodograph equations. It has been shown that many problems of flow with gravity can be solved.
(*g*) The possibility of solving potential flow problems through numerical solution of the hodograph equation has been established and demonstrated by solving a flow discharge through straight-wall channel. The results showed excellent agreement with Von Mises results in the incompressible flow regime for zero approaching flow velocity. Contracting coefficients with any approaching flow velocity within the compressible flow regime have been obtained. For the incompressible channel flow, the problem is solved when the gravitational influence is taken into account. The problem of a free overfall has also been solved in a similar manner. Problems of flows with a sluice gate, sharp crested weirs have also been solved and not yet published. Extensions to curved solid boundaries and to compressible flow regimes are being carried out.
(*h*) **Numerical Solutions of the Compressible Hodograph Equation,** S. K. Liu, W. L. Chow, *AIAA J.* **16,** 2, pp. 188-189, 1978.
Hydrodynamic Solution for Incompressible Flow as Influenced by Gravitation, W. L. Chow, T. Han, C. Wu, *AIAA J.* **16,** 10, pp. 1097-1098, 1978.
Inviscid Solution for the Problem of Free Overfall, W. L. Chow, T. Han, *J. Applied Mech.* **46,** 1, pp. 1-5, 1979.

062-10916-000-50

VISCID–INVISCID INTERACTION FOR THE INCOMPRESSIBLE SEPARATED FLOWS

(*b*) National Aeronautics and Space Administration.
(*c*) W. L. Chow, Professor of Mechanical Engineering.
(*d*) Theoretical basic research, Doctoral thesis.
(*e*) It is the intention of this investigation to demonstrate that all separated flow problems are governed by viscid-inviscid interaction, and to develop a flow model to account for this interaction.
(*g*) A model has been developed to study the steady incompressible flow past a backward facing step within the turbulent flow regime, the corresponding inviscid flow field is established from a free streamline theory with some unknown characteristic parameters and the viscid-inviscid interaction is manifested from the fact that these parameters are to be determined from viscous flow analyses. The method of conformal mapping is applied to establish the inviscid flow and an integral analysis is adopted for the viscous flow processes. The results obtained agreed with the experimental data. Extension to cases of steady flow past wedges has also been carried out. The case of a finite jet thickness with a backstep configuration has been investigated.
(*h*) **Viscid-Inviscid Interaction of Two-Dimensional Incompressible Separated Flows,** W. L. Chow, D. J. Spring, *J. Applied Mech.* **43,** 3, pp. 387-395, Sept. 1976.
Viscid-Inviscid Interaction Associated with Incompressible Flow Past Wedges at High Reynolds Numbers, N. R. Warpinski, W. L. Chow, *NASA CR 135246*, Aug. 1977.
Influence of Free Surface on Incompressible Separated Flows, C. M. Rhie, *Master of Science Thesis*, Dept. Mech. and Ind. Engr., Univ. of Ill. at Urbana-Champaign, Urbana, Ill., 1978.

062-10917-090-50

NUMERICAL SOLUTION OF THE POTENTIAL EQUATION WITHIN THE TRANSONIC FLOW REGIME

(*b*) NASA, U.S. Army Research Office.
(*c*) W. L. Chow, Professor of Mechanical Engineering.
(*d*) Theoretical, basic and applied research.
(*e*) In the study of the performance of airbreathing propulsive systems, the flow past a boattail simulating Nacelle of a Jet Engine within the Transonic Flow Regime must be successfully analyzed. The difficulty of this task is well known as the equation governing the inviscid flow is of the mixing character. In addition, the viscous boundary layer offers considerable modification of the equivalent inviscid body configuration that its effect must be taken into account. Method must be developed to deal with these special features of the problem.
(*g*) It has been learned from numerical solution of the potential equation that even for a slender body with a boattailed configuration, the small disturbance equation will not yield accurate results on the afterbody and the full potential equation must be employed. The finite difference formulations are different for locally subsonic or supersonic flows. The viscous effects are accounted for by correcting the corresponding inviscid body configuration from the displacement consideration. The modification on the pressure distribution is indeed significant as a result of this correction and the final results are in excellent agreement with the experimental data. Extension to flows with angle of attack is being pursued. The established capability of numerical solution of the fully potential equation provided also the opportunity to study the transonic base pressures and transonic separated flows.
(*h*) **Numerical Calculation of Transonic Boattail Flow,** W. L. Chow, L. J. Bober, B. H. Anderson, *NASA TN D-7984*, 1975.
Strong Interaction Associated With Transonic Flow Past Boattails, W. L. Chow, L. J. Bober, B. H. Anderson, *AIAA J.* **13,** 1, pp. 112-113, 1975.
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Transonic Flow Past a Backward Facing Step, W. L. Chow, T. S. Shih, *AIAA J.* **15,** 9, pp. 1342-1343, 1977.
Base Pressure Problems Associated with An Axisymmetric Transonic Flow Past a Backward Facing Step, S. K. Liu, W. L. Chow, *ME-TR-395-5*, Dept. of Mech. and Ind. Engr., Univ. of Ill., *ME-TR-395-3*, report prepared for the Research Grant U.S. Army DAAG29-76-G-0199, ADA050658, Nov. 1977.

062-10918-000-00

THE EFFECT OF BODY FORCES ON FLUID FLOW

(*c*) L. S. Yao, Department of Mechanical and Industrial Engineering.
(*d*) Theoretical basic research.
(*e*) Theoretical studies and numerical solutions of internal or external flow under the influence of buoyancy and centrifugal force have been carried out. The studies promote the understanding of three-dimensional flow development.
(*g*) Many useful results have been obtained and can be applied to various engineering designs such as oil drilling, heat exchangers, boundary-layer control, chemical reactors, nuclear reactors, thermal storage, etc.
(*h*) **Entry Flow in a Curved Pipe,** L. S. Yao, S. A. Berger, *J. Fluid Mech.* **67,** 1977, 1975.
Buoyancy Cross-Flow Effects in the Boundary Layer on a Heated Longitudinal Horizontal Cylinder, L. S. Yao, I. Catton, *J. Heat Transfer, Trans. ASME, Series C.,* **99,** 122, 1977.
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Free-Forced Convection in the Entry Region of a Heated Straight Pipe, L. S. Yao, *J. Heat Transfer, Trans. ASME, Series C,* **100,** 212-219, 1978.
Free-Forced Convection Along a Horizontal Longitudinal Cylinder, L. S. Yao, I. Catton, J. M. McDonough, *Numerical Heat Transfer* **1,** pp. 255-266, 1978.
Variable Viscosity Effect on the Laminar Water Boundary Layer on Heated Cones, L. S. Yao, *J. Applied Mech.* **45,** 3, pp. 481-486, Sept. 1978.
Flow in a Heated Curved Pipe, L. S. Yao, S. A. Berger, *J. Fluid Mech.* **88,** 2, pp. 339-354, 1978.
Entry Flow in a Heated Tube, L. S. Yao, *J. Fluid Mech.* **88,** p. 465, 1978.
Heat Transfer and Shear Stress on a Heated Cone, L. S. Yao, I. Catton, J. M. McDonough, *J. Applied Mech.* **45,** pp. 952-953, 1978.

062-10919-190-00

INSTABILITY OF NATURAL CONVECTION OF A HEAT GENERATING FLUID IN A VERTICAL CYLINDER

(*c*) Robert F. Bergholz.
(*d*) Experimental, theoretical, basic research.
(*e*) This is an experimental and computational study of hydrodynamic instability in the convective Flow of a heat generating fluid in a vertical tube. Flow visualization studies are being performed to investigate the various transition regimes for the flow and relate these to the computational results.

062-10920-060-00

CONVECTIVE FLOWS AND FLOWS OF STRATIFIED FLUIDS IN HELE-SHAW CELLS

(*d*) Experimental, basic research.
(*e*) Experiments are being conducted to study the convective flow due to lateral heating and internal heating in a Hele-Shaw cell in order to simulate these processes in a porous medium. The hydrodynamics of the flow of density stratified fluids in the Hele-Shaw cell is also being investigated.

INDIANA UNIVERSITY, Department of Geology, 1005 East Tenth Street, Bloomington, Ind. 47401. Dr. Haydn H. Murray, Department Chairman.

063-10564-870-00

DETERMINATION OF ORGANIC POLLUTANTS IN URBAN HYDROLOGY

(*c*) Professors Warren Meinschein and Robert Ruhe.

INGERSOLL-RAND RESEARCH, INC., Fluid Mechanics and Thermal Sciences Section, P.O. Box 301, Princeton, N. J. 08540. Dr. W. A. McGahan, Director of Research.

064-10613-260-34

INJECTOR FOR CONTINUOUS INJECTION INTO A PIPELINE OF RUN OF THE MINE COAL FROM A CONTINUOUS MINER–JET PUMP MODEL STUDY.

(*b*) U.S. Department of Energy.
(*c*) R. Malsbury, R. Eakin, T. Haviland, W. Pirtle.
(*d*) Experimental and analytical; applied research and development.
(*e*) A study involving the design and development of a coal injector for coarse slurry transport.
(*g*) An investigation during the first phase of this project concluded that a jet pump injector was the most appropriate

device for receiving dry coal from an underground continuous coal miner and injecting it into a hose. An experimental model established design parameters as well as operational problems. A low pressure loss slurry concentration was subsequently developed for the model jet pump to increase haulage system control. A study was completed to determine the best means of integrating the injector into a complete hydraulic haulage system. This project to date has shown the injector to be a light, compact, rugged, and mobile interface between dry coal mining and hydraulic haulage.

(*h*) Phase I and Phase II Reports submitted to sponsor.

064-11600-630-00

SURGE CONTROL OF CENTRIFUGAL COMPRESSORS USING CLOSE COUPLED RESISTANCES

(*c*) Dr. G. W. Pfannebecker.
(*d*) Experimental and analytical; applied research and development.
(*e*) Aerodynamic characteristics of centrifugal compressors are investigated for the flow range in the normally unstable region. Means of extending the stable operating range are examined. Close coupled flow resistances were developed to extend the stable operating range.
(*f*) Completed.
(*g*) Properly designed close coupled flow resistances provide stable operation of a typical industrial centrifugal compressor stage down to 40 percent of the normal surge flow. This is achievable with hardware the configuration of which is practical and with attendant additional losses that are not prohibitive.
(*h*) **Considerations for the Control of Surge in Dynamic Compressors Using Close Coupled Resistances,** J. L. Dussourd, G. W. Pfannebecker, S. K. Singhania, in *Centrifugal Compressor and Pump Stability, Stall and Surge, ASME,* 1976.
An Experimental Investigation of the Control of Surge in Radial Compressors Using Close Coupled Resistances, J. L. Dussourd, G. W. Pfannebecker, S. K. Singhania, *J. Fluids Engrg., Trans. ASME, Series I* **99,** 1, Mar. 1977.

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INTERNATIONAL BUSINESS MACHINES CORPORATION, Research Laboratory, Dynamic Systems Modeling Group, 5600 Cottle Road, San Jose, Calif. 95193. D. E. Rosenheim, Laboratory Director.

065-10921-270-00

NUMERICAL METHODS FOR INVESTIGATION OF AXOPLASMIC TRANSPORT

(*c*) W. E. Langlois, K02/282.
(*d*) Theoretical, basic research.
(*e*) The mechanism by which nutrients, etc., are transported along nerve axons is a topic of contemporary interest. The purpose of this work was to develop those methods of numerical fluid dynamics which are relevant to the subject.
(*f*) Completed.
(*h*) **Hydrodynamics of Neurons,** W. E. Langlois, Ki-Jun Lee, *Computer Methods in Appl. Mechanics and Engineering* **7,** p. 219-242, 1976.
Hydrodynamics of Neurons: A Postscript, W. E. Langlois, *Computer Methods in Appl. Mechanics and Engineering* **12,** p. 153, 1977.

065-10922-090-00

DIGITAL SIMULATION OF FLUID FLOW IN THE CZOCHRALSKI CRYSTAL-GROWING PROCESS

(*c*) W. E. Langlois, K02/282.
(*d*) Theoretical; basic research.
(*e*) Finite-difference methods are used to simulate the time-dependent flow in a crystal-growing process in which the crystal is slowly extracted from a crucible containing the melt. Either the crystal or the crucible, or both, may be rotated. It is generally believed that the properties of the crystal depend on the flow patterns in the melt, and this provides the motivation for this research.
(*g*) It appears that the possibilities are even more complicated than was expected. Under a wide range of conditions, the flow at large time approaches an oscillation rather than a steady state. Moreover, the effects of centrifugal pumping, buoyant convection–and thermocapillary flow as well–can be strongly coupled. Since Czochralski growth takes place under conditions where the flow patterns cannot be directly observed, and since room temperature flow-visualization studies scale poorly, the value of digital simulation for developing intuition about flow within the melt is significantly augmented.
(*h*) **Vorticity-Streamfunction Computation of Incompressible Fluid Flow With An Almost-Flat Free Surface,** W. E. Langlois, *Appl. Mathematical Modeling* **I,** p. 196-198, 1977.
Digital Simulation of Flow Patterns in the Czochralski Crystal Pulling Process, W. E. Langlois, C. C. Shir, *Computer Methods in Appl. Mechanics and Engineering* **12,** p. 145-152, 1977.
Digital Simulation of Czochralski Bulk Flow in a Parameter Range Appropriate for Liquid Semiconductors, W. E. Langlois, *J. Crystal Growth* **42,** p. 386-399, 1977.
Direct Solution of the Equation for the Stokes Stream Function, G. H. Golub, W. E. Langlois, *Computer Methods in Appl. Mechanics and Engineering,* (in press).
Czochralski Bulk Flow in the Growth of Garnet Crystals, W. E. Langlois, *Proc. 6th Intl. Conf. Numerical Methods in Fluid Dynamics,* Tbilisi, USSR, June 1978.
Effect of the Buoyancy Parameter on Czochralski Bulk Flow in Garnet Growth, W. E. Langlois, *J. Crystal Growth,* (in press).
Crucible With Convex-Inward Bottom for Oxide Crystal Growth, W. E. Langlois, *IBM Technical Disclosure Bulletin,* (in press).

065-10923-000-00

NUMERICAL SOLUTIONS OF FLUID FLOW BETWEEN CO-ROTATING DISKS

(*c*) J. E. Fromm, K02/282.
(*d*) Theoretical, basic research.
(*e*) Finite differences were applied to a small region at the outer edge of a pack of co-rotating disks (a periodic control volume). The rotational flow was studied in the presence of a specified radial flow. Several cases were calculated with varying Rossby and Ekman numbers. The objective was to observe the development of the Ekman boundary layer and its behavior at the disk edge.
(*f*) Completed.
(*h*) **Exit Region Central Source Flow Between Finite Closely Spaced Parallel Co-Rotating Disks,** *Phys. Fluids* **20,** 176, 1977.

065-10924-000-00

NUMERICAL SOLUTIONS OF FLOW GENERATED BY AN IMPULSIVELY ROTATED CYLINDER

(*c*) J. E. Fromm, K02/282.
(*d*) Theoretical, basic research.
(*e*) Studies of fluid flow between counter-rotating cylinders were extended to consider impulsive start flow in an infinite medium. The generation of Taylor cells and ultimate chaotic flow from the initial Couette boundary layer were the observed properties of this flow. A "far from center" approximation was used to allow for large swirl Reynolds number calculation. The object of the study was to ascertain the degree to which Taylor cells persist at late times.
(*f*) Completed.
(*h*) **Flow Near an Impulsively Rotated Circular Cylinder,** *IBM Research Report RJ2383 (31685)* Nov. 1978.

065-10925-000-00

NUMERICAL STUDY OF THE DYNAMIC PRESSURE BETWEEN VIBRATING PARALLEL PLATES

(*c*) J. E. Fromm, K02/282.

(*d*) Theoretical, basic research.
(*e*) Time dependent flow between parallel plates vibrating in a transverse direction are studied by a finite difference method. The moving boundary problem is approximated by stationary plates with a time varying "porous" flow, since small relative motion of the plates is of current interest. The objective is to determine the phase relationship between applied motion and the pulsatile flow produced at various vibration frequencies and assymetrically applied pressures.
(*g*) Results have been obtained for a number of cases but these have not yet been documented. Novel numerical techniques were employed for the calculations.

065-10926-050-00

NUMERICAL STUDY OF THE CAPILLARY JET INSTABILITY

(*c*) J. E. Fromm, K02/282.
(*d*) Theoretical, basic research.
(*e*) The nonlinear, time dependent free surface problem is treated by a mixed primative equation-vorticity streamfunction formulation. A uniform finite difference net plus Lagrangian surface particles define the flow region. The flow parameters are Reynolds number, Weber number and wave length to diameter ratio. The object of the study is to provide understanding of the unstable jet behavior.
(*g*) Several results have been obtained in the range of Reynolds numbers of 50 to 200 with Weber number of 1. Currently complete breakup cannot be followed.

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INTERNATIONAL BUSINESS MACHINES CORPORATION, Thomas J. Watson Research Center, Post Office Box 218, Yorktown Heights, N. Y. 10598. R. E. Gomory, IBM Vice President and Director of Research.

066-07367-810-20

ENVIRONMENTAL SCIENCES-HYDROLOGY

(*c*) J. R. Wallis.
(*d*) Basic and applied research.
(*e*) Stochastic hydrology.
(*h*) **Some Comparisons of Flood Statistics in Real and Log Space,** J. Landwehr, N. C. Matalas, J. R. Wallis, *W.R.R. ces Research 14:5*, 902-920, 1978.
An Algorithm Based on Probability Weighted Moments for Estimating the Parameters of the Wakeby Distribution, J. Landwehr, N. C. Matalas, J. R. Wallis, *W.R.R.*. In Press.
A Real Time Rainfall Model for an On Line Flood Warning System, E. Todini, J. R. Wallis, *Amer. Geophysical Union Chapman Conf.*, Pittsburgh, May 1978.
The Arno River Flood Study (1971-1976), L. Panattoni, J. R. Wallis, *EOS* **60:1**, 1-5, 1979.
Probability Weighted Moments: Definition and Application, J. A. Greenwood, J. M. Landwehr, N. C. Matalas, J. R. Wallis, *W.R.R.* In Press.
Estimation of Parameters and Quantiles of Wakeby Distributions. Part I, Known Lower Bounds, J. M. Landwehr, N. C. Matalas, J. R. Wallis, *W.R.R.*. In Press.
Estimation of Parameters and Quantiles of Wakeby Distributions. Part II, Unknown Lower Bounds, J. M. Landwehr, N. C. Matalas, J. R. Wallis, *W.R.R.*. In Press.
Probability Weighted Moments Compared With Some Traditional Techniqes in Estimating Gumbel Parameters and Quantiles, J. M. Landwehr, N. C. Matalas, J. R. Wallis, *W.R.R.*. In Press.
A Reply To Krishan P. Singh, J. M. Landwehr, N. C. Matalas, J. R. Wallis, *W.R.R.*. In Press.

066-09992-300-00

ENVIRONMENTAL SCIENCES-GEOMORPHOLOGY

(*c*) J. S. Smart.
(*d*) Basic research.
(*e*) Fluvial geomorphology.
(*h*) **The Analysis of Drainage Network Composition,** J. S. Smart, *Earth Surface Processes* **3,** pp. 129-170, 1978.

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IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY, Department of Agricultural Engineering, Ames, Iowa 50011. Dr. H. P. Johnson.

067-10927-870-00

SEDIMENT, NUTRIENT AND PESTICIDE TRANSPORT FROM AGRICULTURAL WATERSHEDS

(*b*) Iowa State University, Agricultural Experiment Station.
(*c*) Dr. H. P. Johnson.
(*d*) Experimental and field investigation; basic and applied research; graduate theses.
(*e*) Field measurements of rainfall and runoff are made; samples are taken at seven locations to determine concentrations of sediment, nitrogen, phosphorus and selected herbicides. Watersheds vary in size from 15 acres to 20 square miles. Computer simulation of flow, and sediment and chemical load is being conducted.
(*g*) There is considerable attenuation of herbicide concentrations between farm fields and small streams at the location.
(*h*) **A Water Balance Model for Deep Loess Soils,** C. E. Anderson, H. P. Johnson, W. L. Powers, *Trans. Amer. Agric. Engrs.* **21, pp. 314-320, 1978.**
Nutrient and Pesticide Movement from Field to Stream: A Field Study, J. L. Baker, M. A. Borcherding, W. R. Payne, from *Best Management Practices, Proc. 1978 Cornell Agric. Waste Management Conf.*, Ann Arbor Science, Ann Arbor, Mich., 1979.
Effect of Tillage System on Runoff Losses of Pesticides, J. L. Baker, J. M. Laflen, H. P. Johnson, *Trans. ASAE* **21,** pp. 886-892, 1978.
Effect of Tillage System on Runoff Losses of Nutrients, S. G. Barisas, J. L. Baker, H. P. Johnson, J. M. Laflen, *Trans. ASAE* **21,** pp. 893-897, 1978.
Soil and Water Loss from Conservation Tillage Systems, J. M. Laflen, J. L. Baker, R. O. Hartwig, W. F. Buchele, H. P. Johnson, *Trans. ASAE* **21,** pp. 881-885, 1978.
Sedimentation Modeling of Impoundment Terraces, J. M. Laflen, H. P. Johnson, R. O. Hartwig, *Trans. ASAE* **21,** pp. 1131-1135, 1978.

067-10928-810-00

DEVELOPMENT OF LAND AND WATER RESOURCES WITHIN CLARION-WEBSTER SOIL AREA

(*b*) Iowa State University, Agricultural Experiment Station.
(*c*) Dr. H. P. Johnson.
(*d*) Experimental and field; applied research; graduate theses.
(*e*) Define physical, economic and institutional interactions, by interview and analyses, involved in improving drainage in northern Iowa drainage districts.
(*h*) **The Effect of Crop Sequence and Nitrogen Fertilizer Levels on Soil Bulk Density of a TYPIC HAPLAQUOLL in Northern Iowa,** N. R. Hagemen, *M.S. Thesis,* 1978.

067-10929-840-00

QUALITY OF TILE EFFLUENT

(*b*) Iowa State University, Agricultural Experiment Station.
(*c*) Dr. J. L. Baker.
(*d*) Field and laboratory investigations; basic and applied research; graduate theses.
(*e*) Analysis of flow to drains; field measurement and sampling of tile effluent.
(*g*) High concentrations of No_3-N are observed in tile effluent discharging from agricultural fields.
(*h*) **Impact of Surface Drainage on Water Quality,** J. L. Baker, H. P. Johnson, *3rd Natl. Drainage Symp. Proceedings. Am. Soc. Agric. Engrs.*, 1977.

Upslope Recharge, Downslope Waterlogging and Interceptor Drains, D. Kirkham, L. Prunty, *3rd. Natl. Drainage Symposium Proceedings, Am. Soc. Agric. Engrs.*, 1977.
Tube Drainage in Stratified Soil Above an Aquifer, M. Najamii, D. Kirkham, M. Dougal, *J. Irrig. Drain. Div., ASCE* **104**, pp. 209-228, 1978.

IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY, Department of Engineering Science and Mechanics, Ames, Iowa 50011. Professor Harry J. Weiss, Department Head.

068-07392-270-40

EFFECT OF STENOTIC OBSTRUCTIONS ON BLOOD FLOW THROUGH ARTERIES

(*b*) Iowa State University Engineering Research Institute.
(*c*) Dr. D. F. Young.
(*d*) Experimental and theoretical; basic research.
(*e*) Project is concerned with steady and unsteady flow of liquids through circular tubes which contain some type of constriction. Flow characteristics which may be of importance to blood flow through arteries containing stenoses are being studied. These include pressure distribution, laminar separation phenomena, transition Reynolds numbers for the initiation of turbulence, and turbulence. Both *in vitro* and *in vivo* tests are under consideration.
(*h*) **Hemodynamics of Arterial Stenoses at Elevated Flow Rates,** D. F. Young, N. R. Cholvin, R. L. Kirkeeide, A. C. Roth, *Circulation Research* **41**, pp. 99-107, 1977.

068-10930-100-54

FLUID BUCKLING

(*b*) Iowa State University Engineering Research Institute; National Science Foundation.
(*c*) Dr. Bruce R. Munson.
(*d*) Experimental, theoretical; basic research.
(*e*) Under certain flow conditions very viscous fluids exhibit buckling phenomena that are in many aspects similar to the buckling of solids. The purpose of this research is to determine the governing mechanisms responsible for such buckling and to determine what the critical (stability) parameters are.

068-10931-240-52

SELF-EXCITED FLUID STRUCTURE INTERACTION

(*b*) Department of Energy, Ames Laboratory; Engineering Research Institute, Iowa State University.
(*c*) Professor Kenneth G. McConnell.
(*d*) Primarily experimental; basic research.
(*e*) When structural elements of circular cross section are subjected to wave type motion, large fluid forces and corresponding structural motion in a direction perpendicular to the wave motion can result. It has been found that self-excited vibrations of large amplitude in the order of one cylinder diameter can result. These large amplitudes of motion occur when structural natural frequencies are integer multiples of the wave frequency. Currently a more sophisticated test apparatus is under construction so that fluid forces acting on a vibrating cylinder can be measured. The overall goal is to understand the basic mechanism causing the vibration and to find methods to control these fluid forces; and thus reduce the self-excited motion and corresponding structural fatigue of critical components.
(*h*) **Modeling Self-Excited Vibrations of Offshore Structures Due to Wave Motion,** K. G. McConnell, T. J. Wilson. Presented *Soc. for Experimental Stress Analysis Ann. Mtg.*, Dallas, Tex., May 1977.

JAYCOR, Fluid Dynamics Group, P.O. Box 370, Del Mar, Calif. 92014. Group Leader: Dr. James H. Stuhmiller.

069-10932-130-82

ANALYSIS OF SPRAY DISTRIBUTION IN AIR AND STEAM ATMOSPHERES

(*b*) Electric Power Research Institute.
(*d*) Theoretical, applied.
(*e*) Develop an understanding and methodology for predicting spray distribution from a nozzle in steam and air environments in order to predict the performance of emergency core coolant during a hypothetical loss of coolant accident in a boiling nuclear reactor.

069-10933-130-82

TWO-PHASE ANALYSES RELATED TO REACTOR SAFETY

(*b*) Electric Power Research Institute.
(*d*) Theoretical, basic and applied.
(*e*) To advance the understanding and ability to calculate two-phase flows pertinent to nuclear reactor safety through the application of a deductive approach to modeling and through a first-principles understanding of small scale processes.
(*g*) The role of interfacial pressure forces in controlling the characteristics of model equations has been discovered. Two-fluid model equations with proper mathematical properties have been obtained from consideration of subscale processes. Direct numerical simulation of bubbly flow has been made. Equations describing the evolution of interfacial area and flow regime have been developed.
(*h*) **A Review of the Rational Approach to Two-Phase Flow Modeling,** J. H. Stuhmiller, *Electric Power Research Inst. Topical Rept. NP-197*, 1976.
The Application of Two-Phase Flow Modeling, J. H. Stuhmiller, *Electric Power Research Inst. Tech. Rept. NP-349*, 1977.
The Physical Processes in Pipe Blowdown, J. H. Stuhmiller, *17th Natl. Heat Transfer Conf.*, Salt Lake City, 1977.
The Influence of Interfacial Pressure Forces on the Character of Two-Phase Flow Model Equations, *Intl. J. Multiphase Flow* **3**, pp. 551-560, 1977.

069-10934-010-26

PREDICTION OF TRANSITION IN TIME DEPENDENT BOUNDARY LAYERS

(*b*) Air Force Office of Scientific Research.
(*d*) Theoretical, basic research.
(*e*) Investigation of the feasibility of numerically calculating the evolution of disturbances in a boundary layer flow from the smallest amplitude to full, three-dimensional, nonlinear motion in order to develop a nonempirical understanding of the transition from laminar to turbulent flow.
(*f*) Discontinued.
(*g*) Numerical methods were developed for calculating two-dimensional disturbances to a boundary layer. The method guarantees proper conservation of volume, momentum, and energy. Time-averaged differencing and direct matrix inversion are used. Calculations have been successfully compared with the results of linear stability theory.
(*h*) **Numerical Calculation of the Stability of Parallel Flows,** J. H. Stuhmiller, *AIAA Journal* **16**, pp. 962-968, Sept. 1978.

069-10935-130-82

ANALYSIS OF STEAM CHUGGING PHENOMENA

(*b*) Electric Power Research Institute.
(*c*) D. A. Sargis.
(*d*) Theoretical, applied.
(*e*) Develop an understanding of steam chugging phenomena that occurs in boiling water reactor steam suppression systems based on first principles analysis of the thermodynamics and fluid dynamics of the system.

(*g*) A computer code, CHUG1, has been developed that incorporates thermodynamic processes in the steam flow and at the water interface and an integral equation formulation of the hydrodynamic pool response. The model has been verified in detail against experimental data. A two-dimensional hydrocode with free surfaces has also been developed to handle large, irregular steam bubbles. A statistical analysis of pool turbulence temperature fluctuations has been made and incorporated into the above models.

(*h*) **Analysis of Steam Chugging Phenomena, Vol. 1: A Fundamental Thermalhydraulic Model to Predict Steam Chugging Phenomena,** D. A. Sargis, J. H. Stuhmiller, S. S. Wang, *Electric Power Research Inst. Rept. NP-962* **1**, Jan. 1979.

Analysis of Steam Chugging Phenomena, Vol. 2: User's Manual for the CHUG1 Computer Program, D. A. Sargis, J. H. Stuhmiller, S. S. Wang, *Electric Power Research Inst. Rept. NP-962* **2**, Jan. 1979.

Analysis of Steam Chugging Phenomena, Vol. 3: SAMPAC Hydrodynamic Pool Response Code, S. S. Wang, J. H. Stuhmiller, *Electric Power Research Inst. Rept. NP-962*, **3**, Jan. 1979.

A Fundamental Thermalhydraulic Model to Predict Steam Chugging Phenomena, D. A. Sargis, J. H. Stuhmiller, S. S. Wang, *Topics In Two-Phase Heat Transfer and Flow, Proc. Winter Ann. Mtg. of the ASME*, pp. 123-133, Dec. 1978.

A Probabilistic Model for Predicting Steam Chugging Phenomena, D. A. Sargis, P. J. Masiello, J. H. Stuhmiller, presented *18th ASME-AIChE Natl. Heat Transfer Conf.*, San Diego, Calif., Aug. 1979.

069-10936-340-82

NUMERICAL SIMULATIONS OF HYDRODYNAMIC RESPONSE OF MARK I SUPPRESSION POOLS

(*b*) Electric Power Research Institute.
(*c*) R. K.-C. Chan.
(*d*) Theoretical and applied research.
(*e*) Two-dimensional and three-dimensional time-dependent numerical models, based on potential flow and finite difference approximations, have been developed to predict the response of a MARK I Suppression Pool which is a part of the cooling system for some types of boiling water reactors (BWR) in nuclear power plants.
(*f*) Completed.
(*g*) The computer codes SURGE, SWELL3, and SWELL2 have been validated against 1/4-scale and 1/12-scale laboratory experiments. The agreement is judged to be good in terms of the down load and the pool surface displacement. Calculations for multi-downcomer cases exhibit more variance from the measurement.
(*h*) **Numerical Simulation of Hydrodynamic Response of Mark I Suppression Pools,** R. K.-C. Chan, et al., *Electric Power Res. Inst. Rept. NP-345*, 1977.

SWELL3/SURGE: Computer Models for Hydrodynamic Response of Mark I Suppression Pools, R. K.-C. Chan, M. J. Vander Vorst, *Electric Power Res. Inst. Rept. NP-835*, 1978.

Calculation of Three-Dimensional Fluid Flow with Multiple Free Surfaces, M. J. Vander Vorst, R. K.-C. Chan, *Proc. ASME Symp. Computational Techniques for Boundary Problems in Applied Mechanics*, San Francisco, Dec. 1978.

069-10937-520-20

CALCULATION OF FLOWS ABOUT A THREE-DIMENSIONAL FLOATING BODY

(*b*) Office of Naval Research.
(*c*) R. K.-C. Chan.
(*d*) Theoretical and basic research.
(*e*) Develop a three-dimensional, time-dependent computer code for calculating wave resistance and detailed flow pattern near the bow and stern for ships of large block coefficient, such as a tanker. Finite difference method and a body-fitted mesh system are used to compute the potential flow. Finite displacement of the free surface and full nonlinearity are included in the model.
(*f*) Continuing.
(*g*) The project has produced some by-products: The Balanced Expansion Technique (BET) for accurate finite difference approximation of the advection term and an improved numerical treatment of outflow boundary condition.
(*h*) **A Balanced Expansion Technique for Constructing Accurate Finite Difference Advection Schemes,** R. K.-C. Chan, *Intl. J. Numerical Methods in Engrg.* **12.**, pp. 1131-1150, 1978.

Finite Difference Simulation of the Planar Motion of a Ship, R. K.-C. Chan, *Proc. 2nd Intl. Conf. Numerical Ship Hydrodynamics*, Berkeley, Calif., 1977.

KANSAS STATE UNIVERSITY, Department of Civil Engineering, Manhattan, Kans. 66506.

071-11701-860-31

PRELIMINARY ANALYSIS OF EFFECT OF CONSERVATION PRACTICES ON WATER BUDGET OF THE SOLOMON BASIN, KANSAS

(*b*) Bureau of Reclamation.
(*c*) Jerome J. Zovne, Assoc. Professor.
(*d*) Theoretical and field investigation; applied research.
(*e*) To collect all available information on soil and water conservation practices in the Solomon Basin. To estimate the impact of conservation practices on runoff in the Solomon Basin.
(*h*) **Soil and Water Conservation Practices Effect on Runoff in the Solomon River Basin, Kansas,** J. J. Zovne, J. K. Koelliker, U.S. Bureau of Reclamation, May 1979 (in press).

Effect of Precipitation on Changing Watershed Yield, J. K. Koelliker, J. Zovne, *Paper No. 79-2022, ASAE Summer Meeting*, Winnipeg, Canada, June 24-27, 1979.

071-11702-870-33

APPLICATION OF CONTINUOUS HYDROLOGIC MODELING TO EVALUATE AND DESIGN WASTEWATER LAND DISPOSAL OR EVAPORATION SYSTEMS

(*b*) Kansas Water Resources Research Institute.
(*c*) Jerome J. Zovne, Assoc. Professor.
(*d*) Theoretical; applied research and design.
(*e*) To develop a continuous hydrologic simulation program to evaluate the performance of wastewater lagoon evaporation and land disposal systems. To formulate guidelines for the design of lagoon evaporation and land disposal systems for Kansas. To prepare a design tool in the form of a computer program for use by agencies of federal and state governments and private consultants in evaluating the site specific performance of lagoon evaporation and/or land disposal wastewater control facilities. To evaluate the reuse potential of wastewater for irrigation in Kansas.
(*h*) **Development and Testing of a Multipurpose Yield Model,** Judith Marie Hayden, *M.S. Thesis*, Dept. Civil Engrg., Kansas State Univ., Manhattan, Kans., May 1979.

071-11703-810-00

EVALUATION OF CONSERVATION PRACTICES AND COVER ON INFILTRATION

(*c*) James K. Koelliker, Assoc. Professor.
(*d*) Applied, experimental field investigation.
(*e*) A rainfall simulator under development will be used to provide water at intensity and energy comparable to natural rainfall onto field plots. Several conditions will be tested, especially stubble mulching to determine differences in infiltration amounts and runoff for agricultural important practices in Kansas.

071-11704-840-33

MODEL TO EVALUATE CONSERVATION, DESIGN AND ECONOMIC FEASIBILITY OF SUPPLEMENTAL IRRIGATION SYSTEMS IN THE SUB-HUMID REGION

(*b*) Office of Water Research and Technology.

(*c*) Jerome J. Zovne, Assoc. Professor.
(*d*) Theoretical and field investigation; applied research.
(*e*) To develop a physical systems model for supplemental irrigation from farm reservoirs which will evaluate the moisture budget of the contributing watershed, the reservoir, and the irrigation area and predict crop yields for various management alternatives. To develop an economic model for supplemental irrigation from farm reservoirs that considers investment and operating costs, returns, and cash flow sequences over an extended period of time. To combine the output from the systems model with the economic model to evaluate the site-specific performance of system and the overall feasibility of the enterprise in the sub-humid region. An actual supplemental irrigation system in Southeast Kansas will be monitored during the project period to further establish the viability of such systems. To develop a publication to aid farmers and other interested parties in the sub-humid region in making rational decisions about supplemental irrigation.

071-11705-820-33

EFFECT OF LENGTH OF FALLOW PERIOD ON WATER STORAGE AND DRAINAGE

(*b*) Kansas Water Resources Research Institute.
(*c*) James K. Koelliker, Assoc. Professor.
(*d*) Field investigation; applied research.
(*e*) The hypothesis that extending the length of fallow with good residue management from 15 to 27 months will result in soil water movement below the rooting depth for wheat (2.5 m) is being tested. Soil moisture storage and movement with time will be monitored to assess the feasibility of the concept as well as provide input data for improving computer simulation capability of the water budget for the soil-water system.

LAMONT-DOHERTY GEOLOGICAL OBSERVATORY of Columbia University, Palisades, N. Y. 10964. Dr. Manik Talwani, Director.

072-08827-450-52

TRANSPORT AND TRANSFER RATE IN THE WATERS OF THE CONTINENTAL SHELF

(*b*) U.S Department of Energy.
(*c*) Dr. Pierre E. Biscaye, Senior Research Associate.
(*d*) Project incorporates experimental and theoretical aspects but it very importantly involves field investigations in the area of basic research.
(*e*) To obtain detailed, quantitative knowledge of the rates of mixing within coastal waters (including the Hudson Estuary) and across the continental slope, and the exchange of water masses and species transported within them between shelf waters and adjacent ocean water masses; and, by improved, quantitative knowledge of the chemical, physical and biological processes which control the origin, dispersal and fate of particulate matter, to understand and ultimately be able to model the impact of energy-related pollutants on the continental shelf.
(*f*) Active through September 1978.

LAWRENCE BERKELEY LABORATORY OF THE UNIVERSITY OF CALIFORNIA, 1 Cyclotron Road, Berkeley, Calif. 94720. Geosciences Division, Division Leader: P. A. Witherspoon.

073-09983-820-52

THERMAL ENERGY STORAGE IN AQUIFERS

(*b*) U.S. Department of Energy.
(*c*) Dr. Chin Fu Tsang.
(*d*) Theoretical; applied research.
(*e*) Detailed studies of the complex three-dimensional fluid and thermal flow patterns of a given aquifer system during injection of hot water and during retrieval later. The purpose of these studies is to understand associated physical processes, to evaluate the efficiency of energy storage and recovery, and to determine the feasibility of using aquifers as storage of hot water produced either as a by-product of electric power plants or from solar energy collectors.
(*g*) High retrieval-storage ratios are found for various storage periods studied.
(*h*) **Underground Aquifer Storage of Hot Water from Solar Energy Collectors,** C. F. Tsang, M. J. Lippman, P. A. Witherspoon, *Proc. Intl. Solar Energy Congress*, New Delhi, India, Jan. 16-21, 1978.
Mathematical Modeling of Thermal Energy Storage in Aquifers, C. F. Tsang, T. Buscheck, D. Mangold, M. J. Lippmann, *Proc. Aquifer Thermal Energy Storage Workshop*, Lawrence Berkeley Laboratory, Berkeley, Calif., May 10-12, 1978.

073-10824-890-31

RESOURCE AND RESERVOIR STUDIES AT THE EAST MESA KGRA

(*b*) U.S. Bureau of Reclamation.
(*c*) Ron C. Schroeder.
(*d*) Applied research.
(*e*) A comprehensive study project has been completed in which the size of the East Mesa geothermal resource was estimated, the fluid production and injection characteristics were simulated, and the fluid chemistry during production and injection was studied.
(*f*) Completed.
(*g*) The fluid flow calculations showed that injection of fluids was necessary to prevent excessive drawdowns and to extract the maximum amount of heat from the reservoir.
(*h*) **Resource and Reservoir Studies at the East Mesa KGRA,** *Lawrence Berkeley Laboratory Report, LBL-7094* (Oct. 1978).

073-10825-890-52

DEVELOPMENT OF THE TWO-PHASE RESERVOIR SIMULATOR SHAFT78 (Project 3/12 of the Italian/American Cooperative Agreement in Geothermal Research).

(*b*) U.S. Department of Energy.
(*c*) Ron C. Schroeder.
(*d*) Theoretical and numerical research.
(*e*) The computer program SHAFT is being improved to include fully coupled mass and energy transport for two-water phases with one additional noncondensible gas component. A new method of solution is being developed to provide faster solution of the coupled integrated-finite-difference equations.
(*g*) The algorithm has been tested extensively for the uncoupled solution method by comparison with analytical solutions and previous numerical calculations.
(*h*) **Studies of Flow Problems with Simulator SHAFT78,** *Proc. 4th Workshop in Geothermal Reservoir Engrg.*, Stanford Univ. (Dec. 13-15, 1978).
Description of the Three-Dimensional Two-Phase Simulator SHAFT78 for Use in Geothermal Reservoir Studies. Presented *Numerical Simulation Symp.*, Denver, Colo. (Feb. 1, 1979), SPE preprint 7699.
SHAFT78, A Two-Phase Multidimensional Computer Program for Geothermal Reservoir Simulation, K. Pruess, R. Schroeder, P. Witherspoon, J. Zerzan, *Lawrence Berkeley Lab. Rept., LBL-8264* (Apr. 1979).

073-10826-890-52

NUMERICAL INVESTIGATION OF GEOTHERMAL PRODUCTION AND INJECTION OF FLUIDS (Projects 3/6, 3/7 and 3/12 of the Italian/American Cooperative Agreement in Geothermal Research).

(*b*) U.S. Department of Energy.
(*c*) Ron C. Schroeder.
(*d*) Theoretical and numerical applied research.

(*e*) Data collected from the Italian geothermal fields in Larderello has been used to construct a model of the Serrazzano and Castelnuovo zones. Geologically accurate computation grids have been constructed and calculations are underway to determine the most likely values of initial and boundary conditions before power production began. The best estimates for reservoir parameters are also being studied. A history match of production and injection data will be made.

(*g*) Regions of recharge and probable closed boundaries have been identified. The behavior of hypothetical two-phase geothermal reservoirs have been studied which show complicated movement of steam and water during long-term production of fluid. The depletion of such reservoirs cannot be estimated by traditional methods for gas reservoirs.

(*h*) **Modeling Vapor-Dominated Geothermal Reservoirs,** R. Marconcini, D. McEdwards, G. Neri, C. Ruffilli, R. Schroeder, O. Weres, P. A. Witherspoon, *Proc. Larderello Workshop on Geothermal Resource Assessment and Reservoir Engrg.* (Sept. 12-16, 1977).

Study of Effects of Reinjection with a Mathematical Model, R. Celati, D. McEdwards, C. Ruffilli, R. Schroeder, O. Weres, P. A. Witherspoon, *Proc. Larderello Workshop on Geothermal Resource Assessment and Reservoir Engrg.* (Sept. 12-16, 1977).

LEHIGH UNIVERSITY, Department of Mechanical Engineering and Mechanics, Bethlehem, Pa. 18015.

074-10938-050-54

SELF-SUSTAINED OSCILLATIONS OF FREE SHEAR LAYERS

(*b*) Volkswagen Foundation, Hanover, West Germany; National Science Foundation, Washington, D.C.

(*c*) Professor Donald O. Rockwell.

(*d*) Basic and applied research involving M.S. and Ph.D. theses.

(*e*) Experimental and theoretical studies of both impinging and nonimpinging free shear layers (planar and axisymmetric jets and mixing layers; wakes) with application of unsteady structural loading and noise generation.

074-10939-010-26

FLOW VISUALIZATION OF COHERENT STRUCTURE OF TURBULENT BOUNDARY LAYERS USING HIGH SPEED VIDEO TECHNIQUES

(*b*) Air Force Office of Scientific Research.

(*c*) Dr. Charles R. Smith, Assoc. Professor.

(*d*) Utilizes experimental flow visualization and hot-film anemometer measurements for basic research on turbulence structure. Is being used as the basis for several M.S. and Ph.D. theses.

(*e*) Flow visualization studies of turbulent boundary layer structure using hydrogen bubble visualization and high speed video recording techniques. Studies are done in a special open water channel system utilizing an axially traversing cart system to allow movement of both the hydrogen bubble-wires and the video viewing system. The video system uses two cameras in a split-screen mode to allow two simultaneous views of the same phenomena to be displayed and recorded. A direct computerized digitizing system allows recorded video pictures to be digitized and fed directly into a minicomputer for quantitative evaluation of instantaneous flow field velocities and acceleration. The objective of the present work is to determine the flow structure characteristics of turbulent boundary layers and the mechanisms by which these structures interact in producing and dissipating turbulent energy, and to establish a rational flow model based on the structure information which can be utilized in future analytical prediction methods.

(*g*) Initial visualization results indicate that structures are very interactive, but can be classified as large outer region structures and smaller inner region structures. Outer region structures appear to be a more passive intertangling of vortex loops in various stages of interaction and decay. Inner region structures appear to originate near the surface as very active loop type vortices. The mechanism for generation of the inner region loop structures appears to be the breakdown of a region of strong shearing near the surface, which is created by the passage of a large outer region structure. Further visual studies employing the two camera video system are now taking place to establish the three-dimensionality of the various structures, and to better define the cause and effect process of turbulence generation. Video digitizing has also been initiated and flow field velocity information should be available shortly.

(*h*) **Interim Report on Coherent Structure of a Turbulent Boundary Layer in a Convected Reference Frame,** C. R. Smith, S. L. Huston, J. J. Brown, *Technical Note CFMTN-77-1*, (*Also AFOSR-TR-77-0793*), School of Mech. Engrg., Purdue Univ., June 1977.

Preliminary Flow Visualization Studies of Coherent Structure in a Turbulent Boundary Layer Using a Moving Reference Frame, C. R. Smith, S. L. Huston, J. J. Brown, *Proc. 14th Ann. Mtg. Soc. Engrg. Science*, Lehigh Univ. Publication, Bethlehem, Pa., pp. 529-540, Nov. 1977.

Design and Development of a Water Channel Flow Visualization System, S. L. Huston, *CFMTR-78-1*, School of Mech. Engrg., Purdue Univ., Jan. 1977.

Visualization of Turbulent Boundary-Layer Structure Using a Moving Hydrogen Bubble-Wire Probe, C. R. Smith, *Proc. AFOSR Workshop on Coherent Structure of Turbulent Boundary Layers*, Lehigh Univ., Bethlehem, Pa., Nov. 1978.

Simulation of a Transverse Vortex in a Turbulent Boundary Layer, C. R. Smith, J. J. Brown, *Lehigh Univ. Rept.*, School of Mech. Engr. and Mech., Dec. 1978.

074-10940-000-54

AN EXPERIMENTAL INVESTIGATION OF FLOW UNSTEADINESS GENERATED BY TRANSITORY STALL IN PLANE-WALL DIFFUSERS

(*b*) National Science Foundation.

(*c*) Dr. C. R. Smith, Assoc. Professor.

(*d*) An experimental investigation, performing basic research on flow steadiness in plane-wall diffusers. At present one thesis has resulted from the work.

(*e*) The effects of flow unsteadiness introduced by transitory stall in plane-wall, subsonic diffusers were investigated using air as the working fluid. A series of twelve fixed geometry diffusers from $L/w_1 = 1.5$ to 6.0 and 2Θ from 8° to 30° were studied using flush mounted pressure trannsducers and hot film anemometers to measure time-varying pressure recovery and throat mass flow rate. Extensive statistical and correlation analysis was done to quantize the flow unsteadiness process. The objectives of the study were to quantize the effect of diffuser geometry and inlet conditions on flow unsteadiness, and to establish a parameteric performance chart to aid the fluid machinery designer in designing stable diffusers.

(*g*) Present results indicate that diffuser flow unsteadiness is basically a low frequency phenomena which appears to be a direct function of time varying stall blockage in the diffuser. Quantitative correlation of unsteadiness as a function of geometry indicates that diffuser unsteadiness behaves systematically and that a geometric region of maximum unsteadiness is definable. A diffuser unsteadiness performance chart has also been developed. Further work is underway to extend the parameter space covered by the design chart, and to explore the effect of upstream and downstream fluid capacitance and resistance elements on unsteady diffuser behavior.

(*h*) **A Note on Diffuser Generated Unsteadiness,** C. R. Smith, *J. Fluids Engrg., Trans. ASME* **97**, 3, pp. 377-379, Sept. 1975.

Transitory Stall Time-Scales for Plane-Wall Air Diffusers, C. R. Smith, *J. Fluids Engrg., Trans. ASME* **100**, 9, pp. 133-138, Mar. 1978.

An Experimental Investigation of Flow Unsteadiness Generated by Transitory Stall in Plane-Wall Diffusers, C. R. Smith, J. L. Layne, *J. Fluids Engrg., Trans. of ASME* **101**, 2, June 1979. Also published in the proceedings of the *ASCE-IAHR-ASME Joint Symp. on Design and Operation of Fluid Machinery* **I**, pp. 167-177, June 1978.

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075-09014-640-54

WIND LOADS ON THREE-DIMENSIONAL STRUCTURES

(*b*) Department of Energy.
(*c*) Leland R. Stein.
(*d*) Theoretical; applied research.
(*e*) Three-dimensional calculations are being performed on high-speed computers to verify that steady-state calculations of wind stresses agree with wind tunnel results. Also being examined are the pressure history on a structure when a unidirectional wind varies suddenly in speed and the effects of a wind that varies rapidly in directions, perhaps simultaneously changing its strength.
(*g*) Three-dimensional steady-state calculations of wind-produced stresses on simple structures agree well with wind tunnel data.
(*h*) **Numerical Simulation of Wind Forces on Structures,** C. W. Hirt, L. R. Stein, *3rd U.S. Natl. Conf. Wind Eng. Res.*, Gainesville, Fla., Feb. (1978).

075-09260-740-20

NUMERICAL STUDY OF FREE SURFACE FLOWS PAST CURVED, RIGID BOUNDARIES

(*b*) Office of Naval Research, Fluid Dynamics Program.
(*c*) B. D. Nichols.
(*d*) Theoretical; applied research; development.
(*e*) Numerical methods are being developed to calculate in two and three dimensions the transient dynamics of free surface flows past arbitrarily shaped bodies. These finite difference techniques are being used to numerically determine hydrodynamic forces on stationary, floating, and impacting cylinders. Particular attention is being given to nonlinear effects.
(*g*) The two-dimensional SOLA-SURF code was used to calculate the added mass and damping coefficients for rectangular and triangular cylinders in forced heave, sway, and roll motions. The numerical data for these calculations are in good agreement with linear theory. At large amplitudes, stronger secondary flow and other nonlinear effects become important. The three-dimensional SOLA-3D code was used to calculate the finite length effects associated with a triangular wedge in sway. It has been determined that the end effects are not significant for low amplitudes of motion for cylinder length to draft aspect ratios greater than two.
(*h*) **Nonlinear Hydrodynamic Forces on Floating Bodies,** B. D. Nichols, C. W. Hirt, *2nd Intl. Conf. on Numerical Ship Hydrodynamics*, Berkeley, Calif., Sept. 1977.

075-10827-690-52

NUMERICAL STUDY OF REACTING FLOW IN A STRATIFIED CHARGE ENGINE

(*b*) Department of Energy.
(*c*) T. D. Butler.
(*d*) Theoretical; applied research; development.
(*e*) A numerical procedure has been developed for numerically simulating the time-dependent multidimensional reacting fluid flows inside the combustion chamber of an internal combustion engine. Our studies have concentrated on the direct-injection stratified charge engine. Among the physical processes included in such calculations are real gas effects, chemical reactions for combustion and pollutant formation, a moving boundary to represent piston motion, turbulence, swirl, wall heat transfer, and a fuel spray model for fuel-injected engines. The method also allows for arbitrary combustion chamber geometry.
(*g*) The feasibility of using modern digital computers to simulate the complex physical processes that occur in the combustion chamber of an internal combustion engine has been demonstrated. The tools that have been developed should prove useful to engine designers.
(*h*) **Toward a Comprehensive Model for Combustion in a Direct Injection Stratified Charge Engine,** T. D. Butler, L. D. Cloutman, J. K. Dukowicz, J. D. Ramshaw, R. B. Krieger, to be publsihed in *Proc. General Motors Research Laboratories Intl. Symp. on Combustion Modeling in Reciprocating Engines*, Warren, Mich. (1978).
CONCHAS: An Arbitrary Lagrangian-Eulerian computer Code for Multicomponent Chemically Reactive Fluid Flow at All Speeds, T. D. Butler, L. D. Cloutman, J. K. Dukowicz, J. D. Ramshaw, Los Alamos Scientific Laboratory report in preparation (1979).

075-10828-130-82

DYNAMICS OF WATER POOLS

(*b*) Electric Power Research Institute.
(*c*) C. W. Hirt.
(*d*) Theoretical; applied research; development.
(*e*) Numerical methods are being developed and used to study the transient, multidimensional dynamics of complicated free surface flows. These finite-difference techniques are being used to study the hydrodynamic forces generated in water pools by rapid injection of air through submerged pipes. Fluid-structure effects are considered, as are effects of limited compressibility.
(*g*) Studies involving detailed comparisons with experimental data have been completed for pool surface impacts on cylindrical pipes and for air bubble growth and collapse from submerged pipes. Present studies include hydrodynamic loads generated on the pool structures, and loads generated in seismic type shaking of the pools.
(*h*) **Numerical Simulation of Hydrodynamic Impact Loads on Cylinders,** B. B. Nichols, C. W. Hirt, *Nuc. Sci. and Eng.* **68**, 143-148 (1978).
Numerical Simulation of BWR Vent Clearing Hydrodynamics, B. D. Nichols, C. W. Hirt, *1978 Annual Meeting ANS*, San Diego, Calif., June (1978).
Hydroelastic Phenomena in Boiling Water Reactor Suppression Pools, B. D. Nichols, C. W. Hirt, *5th Intl. Conf. on Structural Mech. in Reactor Technology*, Berlin, W. Germany, Aug. (1979).

075-10829-390-52

TRANSPORT OF UNDERGROUND WATER AND HEAT IN THE EXTRACTION OF GEOTHERMAL ENERGY FROM HOT DRY ROCKS

(*b*) Department of Energy.
(*c*) Ruth B. Demuth.
(*d*) Theoretical; applied research; development.
(*e*) A numerical calculation technique for high-speed computer is being developed and applied to the investigation of heat and water transport between the primary fracture in hot underground rocks and the lateral thermal fractures that are produced by cooling. The research is closely correlated with field experiments being carried out by this laboratory, aimed towards the development of practical geothermal energy extraction techniques.
(*g*) Calculations are indicating significant enhancement of energy extraction as a result of water circulation through the thermal cracks.
(*h*) **Thermal Fracture Effects in Geothermal Energy Extraction,** R. B. Demuth, F. H. Harlow, Los Alamos Scientific Laboratory report in preparation.

075-10830-130-55

CRITICAL TWO-PHASE FLOW

(*b*) Nuclear Regulatory Commission, Division of Reactor Safety Research.
(*c*) J. R. Travis.
(*d*) Theoretical, applied research.
(*e*) The one- and two-dimensional equations for two-phase flows are being solved numerically to investigate geometric and nonequilibrium effects in critical steam-water flows for a postulated loss-of-coolant accident condition. The results are being compared with semiscale blowdown experiments (experiments conducted at the Idaho National Engineering Laboratory) and full scale blowdown experiments (experiments conducted at the Maraviken Test Station in Sweden).
(*g*) Comparisons of the calculated results and data have shown excellent agreement.
(*h*) **Multidimensional Effects in Critical Nozzle Flows,** J. R. Travis, C. W. Hirt, *Los Alamos Scientific Lab. Rept. LA-NUREG-6934-PR* (Aug. 1977).
The Effects of the Throat Length to Throat Diameter Ratio in Critical Nozzle Flows, J. R. Travis, C. W. Hirt, W. C. Rivard, Los Alamos Scientific Lab. Rept. LA-7195-PR (Apr. 1978).
Large-Scale Critical Flow Analysis, J. R. Travis, W. C. Rivard, *Los Alamos Scientific Lab. Rept. LA-7567-PR* (Dec. 1978).
Multidimensional Effects in Critical Two-Phase Flow, J. R. Travis, C. W. Hirt, W. C. Rivard, *Nucl. Sci. Eng.* **68,** 3, pp. 338-348 (Dec. 1978).
A Nonequilibrium Vapor Production Model for Critical Flow, W. C. Rivard, J. R. Travis, *Nucl. Sci. Eng.* (submitted for publication).

075-10831-190-55

DYNAMICS OF DROPLET FLOW THROUGH OBSTACLE ARRAYS

(*b*) Nuclear Regulatory Commission, Division of Reactor Safety Research.
(*c*) Hans Ruppel.
(*d*) Theoretical; applied research.
(*e*) Water droplets de-entrained on internal structures in the upper plenum of a light water reactor can provide an additional water source for core cooling under accident conditions. Numerical calculations are being performed to aid in understanding the dynamics and important physical mechanisms for the flow of a spectrum of droplets through a structure array. Results of the calculations will be compared with observations from experiments currently underway.
(*g*) Collective effects of multiple obstacles yield capture efficiencies that cannot be extrapolated from results obtained for single cylinders.

075-10832-240-55

FLUID-STRUCTURE INTERACTION

(*b*) Nuclear Regulatory Commission, Division of Reactor Safety Research.
(*c*) W. C. Rivard.
(*d*) Theoretical, applied research.
(*e*) The three-dimensional equations for two-phase flow coupled with the three-dimensional equation for a cylindrical elastic shell are being solved numerically to investigate the core support barrel dynamics and stress states in a German design pressurized water reactor during postulated loss-of-coolant accident conditions. The calculated results are to be compared with observations from full scale tests.
(*g*) Comparisons with data from small scale tests have shown favorable agreement.
(*h*) **Computer Simulation of the Hydroelastic Response of a Pressurized Water Reactor to a Sudden Depressurization,** J. K. Dienes, C. W. Hirt, L. R. Stein, *Los Alamos Scientific Lab. Rept. LA-NUREG-6772-MS* (Apr. 1977).
Fluid-Structure Response of a Pressurized Water Reactor Core Barrel During Blowdown, W. C. Rivard, M. D. Torrey, *Los Alamos Scientific Lab. Rept. LA-7404* (Sept. 1978).
Numerical Simulation of Three-Dimensional Fluid-Structure Response, W. C. Rivard, M. D. Torrey, *Proc. Amer. Nucl. Soc. Topical Mtg. Computational Methods in Nuclear Engrg.*, Williamsburg, Va., Apr. 23-25, 1979.
Hydroelastic Effects of a Loss-of-Coolant in a Pressurized Water Reactor, J. K. Dienes, C. W. Hirt, L. R. Stein, M. D. Torrey, *Proc. 5th Intl. Conf. Structural Mechanics in Reactor Technology*, Berlin, W. Germany, Aug. 13-17, 1979.

075-10833-130-52

PARTICLE-FLUID NUMERICAL MODEL FOR LIQUID SPRAYS

(*b*) Department of Energy.
(*c*) J. K. Dukowicz.
(*d*) Theoretical; applied research; development.
(*e*) A numerical technique has been developed to calculate the dynamics of fuel droplet sprays. The method employs discrete particles which are statistically assigned individual attributes such as size, temperature, and composition. The particles interact with the gas by exchanging mass, momentum, and energy and by volume displacement. The gas is considered to be a compressible mixture of vapor and a noncondensable component. An implicit numerical formalism is used which permits the computation of strong coupling between the particles and the gas which occurs in fine sprays.
(*g*) This technique, embodied in a code called SOLA-SPRAY, has been successfully used to compute the injection, penetration, and subsequent evaporation of a volatile (n-octane) liquid spray in a stratified charge engine cylinder. Other applications have included the computation of the de-entrainment of water droplets by control rods in nuclear reactor safety studies.
(*h*) **A Particle-Fluid Numerical Model for Liquid Sprays,** J. K. Dukowicz, submitted for publication in *J. Comp. Phys.* (1979).
Toward a Comprehensive Model for Combustion in a Direct Injection Stratified Charge Engine, T. D. Butler, L. D. Cloutman, J. K. Dukowicz, J. D. Ramshaw, R. B. Krieger, to be published in *Proc. General Motors Research Laboratories Intl. Symp. on Combustion Modeling in Reciprocating Engines*, Warren, Mich. (1978).

LOUISIANA STATE UNIVERSITY AND A&M COLLEGE, Louisiana Water Resources Research Institute, Baton Rouge, La. 70803. Elvin J. Dantin, Director of Institute.

076-11004-350-33

PHYSICAL AND ECONOMIC CONSEQUENCES OF FAILURE OF THE OLD RIVER CONTROL STRUCTURE

(*b*) Louisiana Water Resources Research Institute for the Office of Water Research and Technology (OWRT) of the U.S. Department of the Interior.
(*c*) Prof. R. G. Kazmann, Civil Engineering; Dr. D. B. Johnson, Economics.
(*d*) Disaster control; applied research.
(*e*) The Old River Control Structure was almost undermined during the flood of 1973. Damage was caused to gas and oil pipelines that cross the Atchafalaya River. The aim of this project is to make a preliminary engineering and economic assessment of the loss of the ORCS. The immediate effect would be to sever most of the gas and oil pipelines that supply the East. Later effects, during dry weather, would be to turn the Mississippi River below Baton Rouge into a salt water estuary with serious consequences to the water supplies of municipalities and industries.
(*f*) Completed.

(*g*) Report being prepared.

076-11005-820-33

USE OF TWIN WELLS AND HEAT PUMPS FOR ENERGY CONSERVATION IN LOUISIANA

(*b*) Louisiana Water Resources Research Institute for OWRT.
(*c*) Prof. E. S. Adler, Mechanical Engr.; Prof. R. G. Kazmann, Civil Engr.
(*d*) Experimental and theoretical; applied research.
(*e*) Water source heat pumps are two or three times as productive as air-source heat pumps that use an equal amount of energy. The groundwater available under most of Louisiana is subject to depletion if the spent water that has been used by the heat pump is placed in a sewer. If, however, the water were reinjected, no depletion would occur. There is, therefore, the problem of well spacing so that the reinjected, heated spent water will not be recycled by the producing well. Moreover, it is possible to improve the performance of a heat pump by increasing the thruput of water. The purpose of this work is to prepare tables to enable the engineer to select the proper well spacing, to prepare maps of depth-to-water and aquifer thickness and depth, and to test commercially available heat pumps to determine the trade-off between additional water and coefficient of performance.
(*g*) No results yet. Project started Oct. 1978.

076-11006-820-33

USE OF BOUNDING WELLS TO COUNTERACT THE EFFECTS OF GRAVITY IN A DIPPING AQUIFER

(*b*) Louisiana Water Resources Research Institute for OWRT.
(*c*) Prof. O. K. Kimbler, Prof. W. R. Whitehead, Petroleum Engr.; Prof. R. G. Kazmann, Civil Engr.
(*d*) Experimental and theoretical.
(*e*) When fresh water is injected into a saline aquifer for later retrieval, and the aquifer is not horizontal, the fresh water tends to migrate updip, away from the point of injection, due to density difference. The purpose of this work is to devise a way, if possible, of operating a system of bounding (peripheral) wells to keep the injected fresh water around the injection well. Such bounding wells may be either injection wells or production wells. If successful the results would be of value in water storage projects, leach mining of metals, and storage and later retrieval of potentially valuable industrial wastes.
(*g*) The computer program proposed to control the movement of fluid updip was verified experimentally in a thin (1/4 in) miniaquifer.
(*h*) **Use of Bounding Wells to Counteract the Effects of Preexisting Groundwater Movement,** W. R. Whitehead, E. J. Langhete, *Water Resource Research* **14,** 2, Apr. 1978.
Use of Bounding Wells to Counteract the Effects of Gravity in Dipping Aquifers, T. E. Williams, *M.S. Thesis*, Dept. of Petroleum Engrg., May 1978, Louisiana State Univ., Baton Rouge, La. 70803.

MANHATTAN COLLEGE, Environmental Engineering and Science Graduate Program, Bronx, N.Y. 10471. Dr. Robert V. Thomann, Director.

077-10941-870-36

APPLICATION AND DEVELOPMENT OF EUTROPHICATION PLANNING MODELS FOR LAKES ONTARIO AND MICHIGAN

(*b*) U.S. Environmental Protection Agency, Large Lakes Research Station, Grosse Ile, Mich. 48138.
(*d*) Theoretical and applied research.
(*e*) This project continues an earlier research grant and further develops large scale models of eutrophication in Lakes Ontario and Michigan with specific emphasis on the verification statistics of a three-dimensional model of phytoplankton in Lake Ontario using the data from the International Field Year on the Great Lakes. The project was also directed towards the first preliminary framework of phytoplankton dynamics in a two layered model of Lake Michigan. Sensitivity analysis and the applicability of near-shore models, specifically the Rochester Embayment in Lake Ontario, to the overall problem of mathematical modeling of eutrophication is addressed.
(*f*) Completed.
(*g*) The project has indicated the substantial difficulty of calibrating the large scale three-dimensional model to time variable data on eutrophication. The importance of hydrodynamic transport in horizontal direction is found not to be as significant as transport in the vertical direction. Near-shore versus open-lake effects in large lakes are of significant importance in eutrophication of the near-shore environment.
(*h*) **On the Verification of a Three-Dimensional Phytoplankton Model of Lake Ontario,** *EPa-600/9-76-016*, ORD, EPA Washington, D.C., pp. 568-572, 1976.
Verification Analysis of Lake Ontario and Rochester Embayment Three-Dimensional Eutrophication Models, (in final preparation).

077-10942-870-36

MODELING OF TOXIC SUBSTANCES IN GREAT LAKES FOOD CHAINS

(*b*) U.S. Environmental Protection Agency, Large Lakes Research Station, Grosse Ile, Mich. 48138.
(*c*) Dr. Robert V. Thomann.
(*d*) Theoretical and applied research.
(*e*) Project is directed towards preliminary construction and evaluation of models of toxic substances transport in the aquatic ecosystem of selected areas of the Great Lakes. Initial emphasis is placed on PCB in heavy metals in Saginaw Bay and PCB in Lake Michigan. In addition, a model of the Great Lakes system in its entirety is to be constructed and mass balance calculations for key toxic substances in the water column sediments and aquatic food chain will be attempted.
(*h*) **Size Dependent Model of Hazardous Substances in Aquatic Food Chain,** *EPA-600/3-78-036*, Apr. 1978.

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078-08069-010-26

AERODYNAMICS-BOUNDARY LAYER

(*b*) Air Force Office of Scientific Research; Office of Naval Research.
(*c*) Dr. K. C. Wang.
(*d*) Theoretical; applied research.
(*e*) Development of numerical methods for exact calculations of steady three-dimensional and unsteady, two-dimensional laminar boundary layers and to examine thereby the nature of such viscous flows, and in particular to study laminar flow near separation.
(*g*) Calculation of three-dimensional laminar boundary layer has been extended to cases involving reversed flow. Ideas developed for three-dimensional steady case are found directly applicable to two-dimensional unsteady case. Separation patterns in general three-dimensional flow have been studied, including typical inclined bodies of revolution, finite wings at incidence and corners between intersecting bodies.
(*h*) **Aspects of "Multi-Time Initial-Value Problem" Originating from Boundary Layer Equations,** K. C. Wang, *Phys. of Fluids* **18,** 8, pp. 951-955, 1975.
Boundary Layer Over a Blunt Body at Low Incidence with Circumferential Reversed Flow, K. C. Wang, *J. Fluid Mech.* **72,** 1, pp. 49-75, 1975.
Concentrated Vortex on the Nose of an Inclined Body of Revolution, T. Hsieh, K. C. Wang, *AIAA J.* **14,** 5, pp. 698-700, 1976.

Separation of Three-Dimensional Flow, K. C. Wang, *Proc. Lockheed-Ga. Co. Viscous Flow Symp., LG77ER0044*, 1977.

Boundary Layer Over Spinning Blunt Body of Revolution at Incidence Including Magnus Forces, K. C. Wang, *Proc. Roy. Soc. London A*. **363**, 357-380, 1978.

078-08695-870-60

PLUME RISE AND DISPERSION MODELS FOR STACK EMISSIONS

(*b*) Maryland Department of Natural Resources.
(*c*) Dr. J. C. Weil.
(*d*) Theoretical laboratory, and field investigation; applied research.
(*e*) Development of simple analytical models for predicting the rise and dispersion of heated stack emissions in flat and complex terrain and testing of the models with both field and wind tunnel data.
(*g*) For the flat terrain situation, recent expressions for plume rise under neutral and convective atmospheric conditions were favorably tested with lidar measurements of a stack plume, and free convection scaling was shown to apply to buoyant stack plumes dispersing in convective mixing layers. For the complex terrain situation, a mathematical model was developed to predict the trajectory and spread of a buoyant stack plume in flow over arbitrarily shaped two-dimensional hill. The model is being verified with both field and wind tunnel data.
(*h*) **Stack Plume Characterization and Model Assessment with Lidar Data,** J. C. Weil, J. L. Altman, presented *NATO/CCMS 9th Intl. Tech. Mtg. Air Pollution Modeling and Its Application*, Toronto, Canada, Aug. 28-31, 1978.
Assessment of Plume Rise and Dispersion Models Using Lidar Data, J. C. Weil, *Maryland Power Plant Siting Program Report PPSP-MP-24*, Feb. 1979.

UNIVERSITY OF MARYLAND, Institute for Physical Science and Technology, College Park, Md. 20742. Dr. J. Silverman, Director.

079-08072-130-50

TWO-PHASE FLOW OF A MIXTURE OF A FLUID AND SMALL SOLID PARTICLES

(*b*) National Aeronautics and Space Administration.
(*c*) Dr. S. I. Pai, Research Professor.
(*d*) Theoretical studies of two-phase flow with application to lunar and planetary problems.
(*e*) The application of two-phase flow theory of a mixture of a gas and small solid particles to volcanic flow and to impact crater has been carried out.
(*g*) The effects of lift force on ejecta transport have been studied. With lift force, the ejecta trajectories differ greatly from those without lift nor in vacuum when the lift effect is large, the trajectory may form loop. Some applications of the lift effect on impact crater have been discussed.
(*h*) **Similar Explosive Eruptions of Lunar and Terrestrial Volcanoes,** S. I. Pai, Y. Hsu, John A. O'Keefe, *Proc. 9th Lunar and Planetary Science Conf.* **2,** pp. 1485-1508, 1978. Pergamon Press, New York.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Department of Civil Engineering, Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, Cambridge, Mass. 02139. Donald R. F. Harleman, Laboratory Director.

Requests for reprints and reports should be addressed to Professor Donald R. F. Harleman, Laboratory Director, Room 48-311, 77 Massachusetts Avenue, Cambridge, Mass. 02139.

081-08084-820-00

ANALYSIS AND PREDICTION OF SUBSURFACE WATER QUALITY

(*c*) Professor J. L. Wilson.
(*d*) Theoretical and experimental; basic research (Master's and Doctoral theses).
(*e*) Several aspects of mass transport in porous media are being explored using mathematical models and laboratory experiments. The emphasis is on phenomena which are of importance in describing and forecasting groundwater quality. Mathematical methods of describing longitudinal dispersion in general nonuniform and unsteady flows are being studied. Also included are mixing phenomena in unsaturated flows and the convective and dispersive mixing process near pumping wells.
(*g*) Exact and approximate solutions for a two-dimensional plume of contaminated groundwater in a uniform flow field are derived. A graphical procedure, designed to ease visualization of the plume, is described to the study of a plume of hexavalent chromium contamination on Long Island.
(*h*) **Two-Dimensional Plume in Uniform Groundwater Flow,** J. L. Wilson, P. J. Miller, *J. Hyd. Div., ASCE, 104(4)*, 503-514, Apr. 1978.

081-08724-430-54

POROUS BREAKWATERS

(*b*) National Science Foundation.
(*c*) Professor O. S. Madsen.
(*d*) Theoretical and experimental; applied research (Master's and Engineer's theses).
(*e*) Determination of the reflection and transmission characteristics of porous rubble-mound breakwaters.
(*g*) A simple yet accurate analytical approach to the determination of the reflection and transmission of relatively long waves normally incident on a porous rubble mound breakwater. An explicit analytical, totally predictive model for the reflection from and transmission through crib-style breakwaters has been developed. For trapezoidal breakwaters the energy dissipation taking place on the seaward slope is evaluated by a combined theoretical and experimental approach and is used in conjunction with the results for the reflection and transmission characteristics of a crib-style breakwater to predict the wave reflection from and transmission through trapezoidal, porous breakwaters. In the present effort an improved theoretical model for the interaction of an incident wave and a porous trapezoidal breakwater has been obtained and an experimental investigation is now in progress.
(*h*) **Reflection and Transmission Characteristics of Porous Trapezoidal Breakwaters,** P. Shusang, *SM Thesis*, Dept. of Civil Engrg, MIT, Jan. 1978.
Wave Transmission Through Trapezoidal Breakwaters, O. S. Madsen, P. Shusang, S. A. Hanson, *Proc. 16th Conf. Coastal Engrg., ASCE*, Aug. 1978.

081-08729-400-00

NUMERICAL MODEL FOR INTERACTING WATER QUALITY PARAMETERS IN ESTUARIES

(*b*) Ford Professorship.
(*c*) Professors D. R. F. Harleman.
(*d*) Theoretical; basic research (Master's and Doctoral theses).
(*e*) An estuary consisting of channels and junctions is modeled mathematically by a network of one-dimensional channels. A finite element model is used for solution of the equations of motion and mass transfer with tidal advection and dispersion included for each branch of the network. These equations are solved, subject to interactions among branches and boundary conditions on the network as a whole, to provide time-dependent concentration distributions for nonconservative water quality parameters. Current research is on the development of a predictive model for interacting water quality parameters such as temperature, salinity, and nutrients under transient tidal, fresh water inflow and variable waste loading conditions.

(*g*) Seven components of the total nitrogen cycle have been included in the model due to their relevance to the study of eutrophic processes in river and estuarine environments. Of the inorganic forms of nitrogen the model includes NH_4^+-N, NO_2^--N and NO_3^--N. The organic forms of nitrogen are phytoplankton-N, zooplankton-N, particulate organic-N (PON) and dissolved organic-N (DON). Simulation runs have been made for the Potomac estuary.

(*h*) **A Comparison of Water Quality Models of the Aerobic Nitrogen Cycle,** D. R. F. Harleman, *Res. Memo. RM-78-34*, Intl. Inst. for Applied Systems Analysis, Laxenburg, Austria, July 1978.

081-08734-440-73

DYNAMICS OF SHALLOW COOLING PONDS

(*b*) Commonwealth Edison Company, Chicago, and NUS Corporation.
(*c*) Professor D. R. F. Harleman; Dr. G. H. Jirka and Dr. M. Watanabe.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) Development of a predictive model for the cooling characteristics of shallow, artificially diked cooling ponds; analysis of specific ponds of this type within the CECO system; development of a user's manual; establishment of design criteria to control pond behavior and maximize cooling efficiency.
(*f*) Completed.
(*g*) Schematic laboratory experiments and analysis of field data have demonstrated the importance of the velocity field on the cooling efficiency. Both lateral circulations in the form of eddies and longitudinal dispersion have significant effects. Criteria have been developed which predict the degree of stratification in a pond as a function of site, shape, loading and mixing. Transient mathematical models have been developed for the lateral circulation and the dispersive effects and applied to the laboratory experiments and prototype tests. Design modifications on several existing ponds have been investigated.
(*h*) **Design and Optimization of Recirculating Cooling Ponds,** E. E. Adams, G. H. Jirka, A. Koussis, D. R. F. Harleman, *Conf. on Waste Heat Management and Utilization*, Univ. of Miami, Dec. 1978.

081-09797-410-44

LONGSHORE SEDIMENT TRANSPORT

(*b*) Sea Grant Office, NOAA.
(*c*) Professor O. S. Madsen.
(*d*) Theoretical; basic and applied research (Master's and Doctoral theses).
(*e*) Development of an analytical model capable of predicting the rate and distribution of longshore sediment transport.
(*g*) Louguet-Higgins' solution for the wave induced longshore current on an infinite, plane beach is adopted in a slightly modified form. Simple correction factors are derived to account for: (1) finite magnitude of the longshore current, (2) finite angle of incidence, and (3) nonlinear wave effects. The current model is calibrated against the experimental data of Galvin and Eagleson to determine values of bottom friction factor and mixing parameter. With the longshore current and bottom friction known a sediment transport relationship, established in previous research, is adopted and longshore sediment transport rates including the variation with distance from shore are calculated. Calculated longshore sediment transport rates are compared with field and laboratory measurements to assess the accuracy of the theoretical model.
(*h*) **A Longshore Current Model,** O. S. Madsen, D. W. Ostendorf, S. S. Reyman, *Proc. of Coastal Zone 78, ASCE* **B**, p. 2332-2341, Mar. 1978.
Longshore Sediment Transport Data: A Review, M. N. Greer, O. S. Madsen, *Proc. 16th Conf. Coastal Engrg., ASCE*, Aug. 1978.

081-09799-870-73

CIRCULATION AND DISPERSION STUDIES AT THE PILGRIM NUCLEAR POWER STATION, ROCKY POINT, MASSACHUSETTS

(*b*) Boston Edison Company.
(*c*) Professor B. R. Pearce.
(*d*) Theoretical (Master's thesis).
(*e*) Mathematical modeling of near and far field convective and dispersive processes in coastal areas. Supplemented by field measurements of physical parameters.
(*f*) Completed.
(*g*) Calculation of the dispersion of winter flounder from Duxbury Bay into Cape Cod Bay. Assessment of the increased cooling water throughout the proposed addition to the Pilgrim Nuclear Power Station and its affect on the resident flounder population in Duxbury Bay.
(*h*) **Circulation and Dispersion Studies at the Pilgrim Nuclear Power Station,** J. Pagenkopf, G. Christodoulou, B. R. Pearce, J. J. Connor, *Tech. Rept. 210*, Ralph M. Parsons Lab. for Water Res. and Hydrodynamics, Dept. Civil Engrg., MIT, Feb. 1976.
Simulation of Larvae Dispersion and Entrainment Near a Coastal Power Station, T. S. Chau, B. R. Pearce, *Tech. Rept. No. 224*, Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, Dept. of Civil Engrg., MIT, July 1977.

081-09800-450-44

THREE-DIMENSIONAL CURRENT MODELING

(*b*) National Weather Service.
(*c*) Professor B. R. Pearce.
(*d*) Basic and applied research.
(*e*) Project involves examination of a model which uses a weighted residual scheme incorporating a depth-varying vertical eddy viscosity to calculate the three-dimensional current structure in coastal areas. Model results will be compared with velocity data from laboratory experiments and field tests, in order to calibrate the model and to obtain an estimate of the vertical variation of the eddy viscosity.
(*g*) The model has been developed and compared with simple analytic solutions for flow in a channel and in a sea of infinite lateral extent. The cases of constant vertical eddy viscosity and linear vertical eddy viscosity were examined. Model results were found to compare very well with the analytic solutions for the linear eddy viscosity model, but not quite as well for the solution using a constant eddy viscosity. The reason for the discrepancy in the latter case can be traced to the nature of the formulation chosen.
(*h*) **A Revised Three-Dimensional Numerical Model to Calculate Currents with a Depth-Varying Vertical Eddy Viscosity,** B. R. Pearce, S. M. Nelson, C. K. Cooper,Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, Dept. of Civil Engrg., MIT.
A Three-Dimensional Numerical Model to Calculate Currents, C. K. Cooper, S. M. Nelson, B. R. Pearce, *Proc. 16th Intl. Coastal Engrg. Conf.*, Hamburg, Sept. 1978.

081-09807-870-73

TRANSIENT ANALYSIS OF DEEP COOLING LAKES WITH SIDE ARM CONVECTION

(*b*) Virginia Electric Power Company.
(*c*) Professor D. R. F. Harleman, Dr. E. E. Adams and Dr. S. Bloss.
(*d*) Experimental and theoretical; basic and applied research (Master's and Doctoral theses).
(*e*) Basic study of the buoyancy driven vertical circulation of cooling water into long shallow side arms of cooling ponds; development of a transient cooling pond model for heat distribution in shallow cooling ponds with lateral and vertical restrictions; development of a two-layered finite element model for solution of the mass heat and momentum conservation equations. Specific application of this investigation is the North Anna Cooling Lake in Virginia.

Long-term predictions of cooling pond behavior under natural and various thermal loading conditions are being made, and compared with pre- and post-operational field measurements.

(*g*) An experimental schematic study of the side arm circulation has been conducted, investigating different boundary conditions at the side arm entrance, bottom slopes and lateral constrictions. An analytical model of the side arm circulation has been developed.

A segmented transient cooling pond model has been formulated for the North Anna Cooling Lake taking account of the distinct geometric features.

A two-layered finite element model for the heat and velocity distributions in the upper layer of a cooling pond has been developed and verified with laboratory data.

Long-term meteorological data has been obtained through multiple correlation with several meteorological stations and subsequent synthetic data generation. Predictions for long-term pond performance have been given.

The existing M.I.T. Deep Reservoir Model has been modified to include the vertical heat transport processes which are generated by the wind shear effect at the water surface.

(*h*) **Analysis of Cooling Effectiveness and Transient Long-Term Simulation of a Cooling Lake with Application to the North Anna Power Station,** G. Jirka, D. Brocard, K. Octavio, M. Watanabe, D. Harleman, *Ralph Parsons Lab. Tech. Rept. No. 232*, Dec. 1977 (supplemantary data report issued Nov. 1977).

Analysis of Possible Design Modification in the Waste Heat Treatment Facility for the North Anna Power Station, R. M. Parsons Lab., unpublished report, June 1977.

Transient Simulation of Cooling Lake Performance Under Heat Loading from the North Anna Power Station, D. Harleman, G. Jirka, D. Brocard, K. Octavio, *Proc. Conf. Waste Heat Management and Utilization*, Univ. of Miami, Dec. 1978.

081-09808-870-54

DYNAMIC ANALYSIS OF NUTRIENT REMOVAL BY WASTE STABILIZATION PONDS

(*b*) Ford Professorship and National Science Foundation.

(*c*) Professor D. R. F. Harleman, Professor N. Tang.

(*d*) Theoretical and experimental; basic research (Master's and Doctoral theses).

(*e*) Develop a method for prediction of the dynamic behavior of aerobic waste stabilization ponds under transient loading and meteorological conditions. A mathematical model has been formulated for use in the design of new ponds as well as for the analysis and improvement of existing facilities. The model applies the "element cycle" method to track the transformation of nutrients into their various organic and inorganic forms.

(*g*) Application of the model at two existing treatment sites has indicated the capability of the model structure to adequately simulate the stabilization pond environment. Calibration and verification runs have established values and ranges for the rate coefficients. The coupling of the hydraulic transport and biogeochemical processes is demonstrated. It is concluded that the optimal design consists of a fully mixed pond followed by a baffled pond. A stabilization pond can be designed to meet secondary treatment objectives which, in terms of oxygen demand and nutrient removals (nitrogen and phosphoros), are generally greater than conventional secondary treatment plants.

(*h*) **A Dynamic Nutrient Cycle Model for Waste Stabilization Ponds,** R. A. Ferrara, *Ph.D. Thesis*, Dept. of Civil Engrg., May 1978.

081-09809-430-52

OCEAN THERMAL ENERGY CONVERSION

(*b*) U.S. Department of Energy, Division of Solar Technology.

(*c*) Dr. E. E. Adams and Professor D. R. F. Harleman.

(*d*) Theoretical and experimental; basic and applied research.

(*e*) Ocean thermal energy conversion (OTEC) plants have been proposed as a method of generating electrical power using the thermal energy difference between the warm upper layer and the cold lower layer of tropical oceans. The external fluid mechanics associated with the plants' evaporator and condenser flows are being studied experimentally and analytically to ascertain whether these plants can fully utilize the available energy potential or whether local recirculations take place which would reduce the plant efficiency. In addition, potential environmental effects associated with the water movement and change in temperature are being addressed.

(*g*) A 1:300 scale model of an OTEC plant has been built in a large thermally stratified, laboratory basin. Discharge and intake configurations, temperatures and flow rates can be varied to simulate different prototype designs. Measurements of temperature, dye concentration and velocity are used to document the flow field and assess recirculation. To date, experiments have been conducted in the absence of a current. These indicate that no significant recirculation should occur for plants up to about 400 MW. Future testing will simulate ocean currents by towing the model plant. Mathematical models based on the integral approach are being developed to compare with the experiments.

(*h*) **Ocean Thermal Energy Conversion Plants: Experimental and Analytical Study of Mixing and Recirculation,** G. H. Jirka, R. P. Johnson, D. J. Fry, D. R. F. Harleman, *R.M. Parsons Tech. Rept. No. 231*, Sept. 1977.

Evaluation of Mixing and Recirculation in Generic OTEC Discharge Designs, D. J. Fry, E. E. Adams, G. Jirka, presented *Vth OTEC Conf.*, Miami Fla., Feb. 1978.

081-09810-870-52

WASTE HEAT MANAGEMENT IN THE ELECTRIC POWER INDUSTRY: ISSUES OF ENERGY CONSERVATIONS AND STATION OPERATION UNDER ENVIRONMENTAL CONSTRAINTS

(*b*) U.S. Dept. of Energy, Division of Environmental Control Technology.

(*c*) Professor D. R. F. Harleman, Dr. E. E. Adams, Dr. L. Glicksman (Mechanical Engineering) Professor K. D. Stolzenbach, and Dr. R. Barbera.

(*d*) Theoretical research and assessments; applied research.

(*e*) Assessment of environmental impacts and energy conservation in waste heat management: Evaluation of the long-term and short-term tradeoff issues which arise from the choice of different cooling systems. Evaluation of regional effects and meteorological and hydrological transients. Investigation of long-term simulation methodologies of transient cooling system behavior.

Development of control technologies for supplementary cooling systems: Investigation of real-time control strategies which can be used to switch between different cooling modes such as to maximize system efficiency while meeting environmental constraints. Case study of the Browns Ferry Nuclear Power Plant as a typical river site offering alternative once-through cooling and cooling tower modes. Development of a probabilistic river temperature model and control algorithm; evaluation of monitoring requirements, regulatory constraints, tower performance characteristics and switching rules.

(*f*) Completed.

(*g*) (1)Procedures for the design of river diffusers, shallow cooling ponds, natural and mechanical draft wet towers and mechanical draft towers have been developed. The operational and construction costs have been compared for a hypothetical study site. (2) Deterministic and stochastic models have been developed to estimate differences between upstream and near site natural river temperatures near Browns Ferry Nuclear Power Plant. Results indicate that (a)the mixed cooling system results in a 10 percent capacity loss compared with the totally closed system, (b) the cooling tower-related capacity loss is extremely sensitive to the specified limit on induced tem-

perature increases and (c) about one-third of the capacity loss incurred using a mixed-mode system is the result of natural temperature variations which are interpreted as plant-induced effects by the monitoring system.

(*h*) **Modeling of Natural River Temperature Fluctuations,** S. A. Freudberg, *S. M. Thesis*, Dept. of C. E., Sept. 1977.
An Environmental and Economic Comparison of Cooling System Designs for Steam-Electric Power Plants, K. F. Najjar, *S. M. Thesis*, Dept. of C. E., Sept. 1978.
Waste Heat Management in the Electric Power Industry: Issues of Energy Conservation and Station Operation Under Environmental Constraints, D. R. F. Harleman, *U.S. DOE Environmental Control Symp.*, Nov. 28-30, 1978, Washington, D.C.

081-09813-870-54

ENVIRONMENTAL EFFECTS OF WESTERN STRIP MINING

(*b*) National Science Foundation Energy Traineeships and the MIT Energy Laboratory.
(*c*) Professors J. L. Wilson.
(*d*) Applied research (Master's and Doctoral theses).
(*e*) A number of important issues relating to the impact of western strip mining on groundwater resources are evaluated. These include the effects of aquifer destruction on available water supply, base flow reduction, aquifer renovation, water chemical quality, and alternative water supplies and water uses.
(*f*) Complete.
(*g*) A finite element model was used to investigate the influence of strip mining features, commonly found in the Northern Great Plains Coal Region, on groundwater hydrology. The features examined were: reclaimed mine geometry, relative transmissivity between the reclaimed spoil and the surrounding unmined coal bed aquifer, anisotropy, the gravity sorted rubble layer, coal wedges left between tranch cuts, and the position and size of an operational mine in the regional flow system.
(*h*) **Influence of Strip Mines on Regional Groundwater Flow,** J. L. Wilson, D. A. Hamilton, *J. Hyd. Div.; ASCE* **104**, 9, 1004-1011, Sept. 1978.
Influence of Western Strip Mines on Groundwater Aquifers, J. Wilson, D. A. Hamilton, *Proc. ASCE Energy-Groundwater Symp.*, Apr. 1978; also *Pre-print No. 3288, ASCE Spring Convention*, Apr. 1978.

081-09814-070-54

DISPERSIVE MIXING OF NEGATIVELY BUOYANT PLUMES IN POROUS MEDIA

(*b*) National Science Foundation.
(*c*) Professor J. L. Wilson.
(*d*) Theoretical and experimental; basic and applied research (Master's thesis).
(*e*) Theoretical and experimental investigation of plumes of denser water which sink as they travel downstream, and which result from the introduction of liquids of a higher density into ambient aquifer flows. The analysis will incorporate the effects of density difference between ambient and aquifer flows, and will account for the effects of hydrodynamic dispersion on the mixing.

081-09819-810-54

HYDROLOGIC ESTIMATION FROM GEOMORPHOLOGY

(*b*) National Science Foundation.
(*c*) Professor Peter S. Eagleson.
(*d*) Theoretical, basic research.
(*e*) In the size, shape and topology of the stream channel network, the landform carries the distinctive signature of the integrated effects of geologically recent fluvial processes. This project seeks to establish relationships between these features and the current climatic and hydrologic regimes with a view toward their use in reducing the uncertainty of hydrologic estimation in the absence of hydrologic data.
(*g*) Hourly and daily precipitation data from stations in six different climates are analyzed for independence of rainfall events and to find the parameters of fitted probability density functions.

081-09820-810-00

THE DISTRIBUTION OF ANNUAL WATER YIELD

(*b*) M.I.T. Sloan Basic Research Fund.
(*c*) Professor P. S. Eagleson.
(*d*) Theoretical; basic research.
(*e*) Probability densities are derived for the separate components of the one-dimensional water balance from the observed probability densities of the climatic variables using the physics of the processes. The exp0ected values of these distributions are used to define the average annual water balance and to gain insight into the dynamic coupling climate, soil and vegetation.
(*f*) Completed.
(*g*) A rational method of climate classification is derived. Derivation of the yield-frequency relation gives, through fitting with observed streamflow-frequency, a method for large-scale parameterization of land surface according to soil type and vegetal density.
(*h*) **Climate, Soil and the Water Balance–A Framework for Their Analytical Coupling,** P. S. Eagleson, *10th John R. Freeman Mem. Lectures of the Boston Soc. of Civil Engrs. Section/ASCE.*
Climate, Soil and Vegetation, Part 1. Introduction to Water Balance Dynamics; Part 2. The Distribution of Annual Precipitation Derived from Observed Storm Sequences; Part 3. A Simplified Model of Soil Moisture Movement in the Liquid Phase; Part 4. The Expected Value of Annual Evapotranspiration; Part 5. A Derived Distribution of Storm Surface Runoff; Part 6. Dynamics of the Annual Water Balance; Part 7. A Derived Distribution of Annual Water Yield; P. S. Eagleson, *Water Resources Research* **14**, 5, Oct. 1978.

081-09821-810-54

SHORT TERM RAINFALL PREDICTION FOR THE REAL TIME CONTROL OF URBAN DRAINAGE SYSTEMS

(*b*) National Science Foundation.
(*c*) Professors R. L. Bras and D. H. Marks.
(*d*) Theoretical; applied research.
(*e*) Real-time decisions for the operation of flood control systems in urban areas depend upon knowledge of the current state and a prediction of future inputs. Due to the relatively fast response of an urban drainage system prediction of future flows requires a short-term prediction of rainfall. This work will develop a methodology to continuously update and forecast estimates of rain-fall using data from a telemetered network.
(*f*) Completed.
(*g*) A multivariate nonstationary model has been developed. Parameter estimation and forecasting procedure was tested with real data.
(*h*) **Short Term Rainfall Prediction: A Nonstationary Multivariate Stochastic Model,** E. R. Johnson, R. L. Bras, *MIT, R. M. Parsons Lab. of Water Resources and Hydrology, Tech. Rept. 233*, Apr. 1978.

081-09822-300-44

ON-LINE RIVER DISCHARGE FORECASTING USING FILTERING AND ESTIMATION THEORY

(*b*) National Weather Service, NOAA, U.S. Department of Commerce.
(*c*) Professor R. L. Bras.
(*d*) Theoretical; applied research.
(*e*) An on-line procedure of estimation and forecast is being developed using the Kalman Filter as the analytical tool to process real time information of rainfall and runoff. The National Weather Service River Forecasting Model is used.

(*g*) Necessary modifications of the National Weather Service Model have been accomplished. The model is solved in a state-space formulation allowing feedback and forecast. Accuracy of obtained forecast is being evaluated. Excellent results have been obtained.

(*h*) **Short Term Forecasting of Rainfall and Runoff,** R. L. Bras, presented *I.I.A.S.A. Workshop on Recent Developments in Real Time Forecasting/Control of Water Resource systems*, Oct. 18-20, 1976.

A Study of Collinearity and Parameter Stability in Rainfall-Runoff Models: Ridge Regression and Kalman Filtering, P. K. Kitanidis, R. L. Bras, *Proc. Amer. Geophys. Union Chapman Conf. Applications of Kalman Filtering to Hydrology, Hydraulics and Water Resources*, Pittsburgh, May 1978.

Error Identification in Conceptual Hydrologic Models, P. K. Kitanidis, R. L. Bras, *Proc. Amer. Geophysical Union Chapman Conf. Applications Kalman Filtering to Hydrology, Hydraulics and Water Resources*, Pittsburgh, May 1978.

Real Time Forecasting of River Flows, P. K. Kitanidis, R. L. Bras, *MIT, R. M. Parsons Lab. for Water Resources and Hydrodynamics, Tech. Rept. No. 235*, June 1978.

081-09825-870-36

CHEMICAL MODELING OF METALLIC WASTE DISPOSAL

(*b*) Environmental Protection Agency.

(*c*) Professor F. M. M. Morel.

(*d*) Applied research.

(*e*) The ultimate goal is to develop a predictive model for the fate and impact of trace metal pollutants in natural waters.

(*f*) Completed.

(*g*) A compact and more efficient computer program for chemical equilibrium calculations has been designed and implemented. Experimental data on adsorption of trace metal on hydrous iron oxide in waters of various salinities have been obtained. Adsorption submodels in accord with these experimental results have been developed.

(*h*) **Adsorption of Trace Metals by Hydrous Ferric Oxide in Seawater,** K. C. Swallow, *Ph.D. Thesis*, Dept. Chemistry, Mass. Inst. Tech., Cambridge, Mass., Jan. 1978.

MINEQL-II: A computer Program for the Calculation of Chemical Equilibrium Composition of Aqueous Systems, J. L. Zachary, F. M. M. Morel, 1978. Ralph M. Parsons Lab. for Water Resources and Environmental Engrg., Dept. of civil Engrg, Mass. Inst. Tech., Cambridge, Mass.

081-09826-870-54

NUTRIENT UPTAKE AND GROWTH OF PHYTOPLANKTON UNDER UNSTEADY CONDITIONS

(*b*) NSF–Engineering.

(*c*) Professors S. W. Chisholm and F. M. M. Morel.

(*d*) Experimental and theoretical; basic research.

(*e*) Experimental examination of the characteristics of nutrient uptake and growth in nutrient limited phytoplankton cultures under transient conditions. A simulation model has been developed to attempt to satisfactorily describe (with three state variables) the dynamics of nutrient uptake and growth of a phytoplankton limited by one nutrient.

(*g*) Initial efforts have focused on a theoretical treatment of three models for the steady state growth of phytoplankton limited by one nutrient. Mathematical analysis of the three models (often presented as alternative models in current literature) proves them equivalent, which forces the conclusion that each model is an equally valid–or equally invalid–statement of algal growth at steady state. Experimental and theoretical research has examined the validity of these models under conditions of unsteady phytoplankton growth.

(*h*) **A Comparison of Two Methods for Measuring Phosphate Uptake by** *Monochrysis lutheri* **Grown in Continuous Culture,** D. E. Burmaster, S. W. Chisholm. Submitted to *J. Exp. Mar. Biol. Ecol.*

The Unsteady Continuous Culture of Phosphate-Limited *Monochrysis lutheri:* **Experimental and Theoretical Analysis,** D. E. Burmaster. Submitted to *J. Exp. Mar. Biol. Ecol.*

Steady and Unsteady Continuous Culture of *Monochrysis lutheri* **Under Phosphate Limitation,** D. E. Burmaster. MIT, *Ph.D. Thesis.*

081-09827-870-54

THE PHASING OF CELL DIVISION IN MARINE DIATOMS: CHARACTERISTICS, MECHANISMS, AND SIGNIFICANCE

(*b*) NSF–Biological Oceanography.

(*c*) Professor S. W. Chisholm.

(*d*) Experimental; basic research.

(*e*) Identify and describe those aspects of phytoplankton growth and physiology that are influenced by daily light/dark cycles. The specific characteristics and control mechanisms of the timing of cell division in individual species will be examined as well as the potential ecological significance of the phenomenon. Inherent in these objectives is the evaluation of the possible impact that the inclusion of rhythmic processes could have on current models dealing with phytoplankton growth.

(*g*) The timing of cell division in a marine diatom *Thalassiosira fluviatilis* is restricted when the cells are grown in a 24-hour light/dark cycle and is regulated by photoperiod and growth rate. Evidence suggests that individual species may show distinctive patterns and that cell size distribution in populations may be an important factor in regulating these patterns. Several hypotheses concerning the phasing mechanism and the adaptive significance of the phenomenon are being considered and tested.

081-10943-420-20

SURFACE WATER WAVES

(*b*) Office of Naval Research, Department of the Navy.

(*c*) Professor C. C. Mei.

(*d*) Theoretical (Master's and Doctoral theses).

(*e*) Hydrodynamic aspect of wave energy extraction. Fluid dynamics near the cut-off frequencies. Ships motion in shallow water. Harbor oscillations Mass transport in waves.

(*g*) A variety of water wave problems is investigated in this project. Wave energy extraction from floating devices are studied for the theoretical efficiency, means of optimization, responses and mooring forces, etc. Techniques (analytical and numerical) are developed for waterwave diffraction and applied to ocean structures, islands, harbors, etc. Nonlinear behavior of water waves.

(*h*) **Numerical Methods in Water-Wave Diffraction and Radiation 10,** C. C. Mei, *Ann. Rev. Fluid Mechanics*, 1978.

Effects of Two-Dimensional Topography on Mass Transport Near the Sea Bottom, J. Lamoure, C. C. Mei, *J. Fluid Mechanics*, 1977.

Nonlinear Oscillations in a Narrow Bay, S. R. Rogers, C. C. Mei, *J. Fluid Mech.*, 1978.

Leakage of Groundwater Through a Slot in a Sheet Pile, C. C. Mei, *J. Hydraulic Research* **15,** 3, 253-259.

081-10944-520-54

SHIP MOTIONS AND WATER WAVES

(*c*) Professor C. C. Mei (and Professors J. N. Newman and R. W. Yeung, Ocean Engineering Department).

(*d*) Theoretical (Master's and Doctoral theses).

(*e*) Ship waves in narrow and shallow canals, critical phenomena in water waves, such as breaking, critical frequency or critical speed. Diffraction of Stokes Waves. Other water wave problems.

(*g*) A variety of theoretical problems are studied. Examples are nonlinear transient waves near certain critical frequencies. Ships moving near critical speed in shallow water and analytical theory of diffraction and radiation by slender islands or floating bodies. Numerical theory of finite elements or finite differences are employed.

(*h*) **Flow Around a Slender Body in Shallow Water,** C. C. Mei, *J. Fluid Mechanics*, Dec. 1976.

Numerical Methods in Water Wave Diffraction and Radiation, C. C. Mei, *Ann. Rev. Fluid Mechanics* **10,** 1978.

Some Theoretical Properties of a Hybrid Element Method for Water Waves, J. A. Aranha, C. C. Mei, D. K. P. Yue, submitted for publication.

081-10945-420-44

HYDRODYNAMIC AND ENGINEERING EVALUATION OF AN OCEAN WAVE ENERGY SYSTEM

(*b*) NOAA–Sea Grant.
(*c*) Professor C. C. Mei and (Prof. A. D. Carmichael, Ocean Engineering Department).
(*d*) Theoretical, experimental and applied.
(*e*) The efficiency of Salter's cam, wave forces on induced motion of the cam. Effects of random waves and nonrigidity of the axis.
(*g*) By using a hybrid finite element technique recently developed, hydrodynamic forces are calculated for a floating cam whose wave-induced rolling can be used to drive a generator. Efficiency, response, and forces are studied for various geometrical parameters. Loss of efficiency due to lack of rigidity in support is investigated. Effects of random waves are computed. This information is basic for estimating the potential of a given design and provides the upper limit of extractable energy which can be strived for in designing the generator.
(*h*) **A Hybrid-Element Method for Three-Dimensional Water Wave Scattering,** D. K. Yue, H. S. Chen, C. C. Mei, *Intl. J. Numerical Method in Engrg.*, 1977.
Characteristics of Salter's Device for Extracting Energy from Ocean Waves, A. E. Mynett, D. Serman, C. C. Mei, to appear in *Applied Ocean Research*, 1979.

081-10946-390-54

STRUCTURE-FLUID INTERACTION DUE TO EARTHQUAKES

(*b*) National Science Foundation (RANN).
(*c*) Professor C. C. Mei.
(*d*) Theoretical (Master's and Doctoral theses).
(*e*) Dam-reservoir interactions and structure-ocean interactions due to earthquakes of high frequency. The effects of fluid compressibility and the structural elasticity are emphasized. A hybrid element method is developed for effective computation.
(*g*) In this project the structural response is investigated when the ground motion at the base of the structure is forescribed. Hydrodynamic forces are primary factors to be considered. Ground impedance is however not considered. Effective analytical and numerical methods are developed to study storage tanks, ocean structures or dams.
(*h*) **Exact and Hybrid Element Solutions for Vibrating Structures Seated on the Sea Bottom,** C. C. Mei, M. A. Foda, P. Tong, to appear in *Applied Ocean Research*, 1979.

081-10947-390-00

INTERACTION OF ELASTIC WAVES AND FLUID WAVES

(*b*) MIT Sloan Fund.
(*c*) Professor C. C. Mei.
(*d*) Theoretical.
(*e*) To study elastodynamic diffraction problems for a half space involving rigid inclusions elastic structures and/or water.
(*g*) The effects of ground impedance are studied in problems of interest to earthquake engineering. Typical cases are dam-reservoir interactions and ocean storage tanks. The response of an engineering structure is studied by including the dynamic reactions not only of water but also of the ground. Analytical and finite element techniques are developed for diffraction and radiation of waves.
(*h*) **Some Identities in the Elastodynamics With Rigid Inclusions,** C. C. Mei, to appear in *J. Acoustical Soc. of Amer.*, 1978.
Resonant Scattering of SH Waves by Overground Structures, C. C. Mei, submitted for publication.
Grazing Incidence of Short Elastic Waves on a Slender Cavity, C. C. Mei, to appear in *Wave Motion*, 1978.

081-10948-410-44

ENGINEERING MODEL OF LONGSHORE CURRENTS

(*b*) Sea Grant–Nearshore Sediment Transport Study (NSTS).
(*c*) Professor O. S. Madsen,
(*d*) Theoretical and experimental, basic and applied research, (Master's and Doctoral theses).
(*e*) A simple predictive model for the velocity field in the nearshore zone resulting from the combined action of winds, waves and tides will be developed. The relative importance of the various forcing functions will be determined from a preliminary linearized model. The importance of accounting for the random nature and the directional characteristics of the incident waves will be investigated. A simple procedure to account for the nonlinear interaction of the wind, wave and tidal velocity field, in terms of the resulting bed shear stress, will be established. Preliminary results will be used to guide the design of a large scale field experiment which is part of the NSTS. The resulting simple engineering model for the velocity field will be compared with the results obtained from the large scale field experiments and may form the basis for the development of an analytical model of sediment transport processes in the nearshore zone.

081-10949-420-44

SURF ZONE HYDRODYNAMICS: A FIELD INVESTIGATION

(*b*) Sea Grant Office–NOAA, Joint MIT-WHOI Research and Doherty Professorship.
(*c*) Professor O. S. Madsen (MIT); Dr. W. D. Grant (WHOI).
(*d*) Experimental and theoretical; basic and applied research (Engineer's and Doctoral theses).
(*e*) The project is a joint project between MIT and Woods Hole Oceanographic Institution (WHOI). The major funding for the project is from Sea Grant; however, funds for instrumentation costs are provided by Joint MIT-WHOI Research Seed Funds. Reliable biaxial electromagnetic current meters and digital wave staffs for use inside and outside the surf zone in moderate wave conditions (breaker heights of the order 2 ft.) have been developed. Field deployment of 4 current meters and 4 wave gages was carried out at Fortune Rock Beach in Maine. Further field experiments are planned. The measurements will be compared with the simple model for wave induced longshore currents developed in the "Longshore Sediment Transport" project. A physically realistic parameterization of bottom friction factor, the lateral shear and a generally valid model for wave induced longshore currents should result from this comparison.

081-10950-220-00

SEDIMENT TRANSPORT BASED ON HYDRODYNAMIC PRINCIPLES

(*c*) Professor O. S. Madsen.
(*d*) Theoretical; basic research (Master's and Doctoral theses).
(*e*) Development of a sediment transport relationship which is based on hydrodynamic principles.
(*g*) Based on available experimental data on lift and drag coefficients the entraining forces acting on a particle on the bed-fluid interface are evaluated for turbulent, unidirectional flow. Statistical properties of the turbulent flow are assumed and Shields Criterion is derived as it applies to a particle in the bed as well as to a particle resting on top of the bed. For flow intensities greater than the threshold of movement expressions for the number of grains moving and their mean velocity is evaluated leading to a bed load transport formula. Based on the bed load formula concentration profiles are determined and used to evaluate the suspended load. Published experimental data are used to tune the model.

081-10951-420-44

WAVE ATTENUATION BY BOTTOM FRICTION

(*b*) Sea Grant Office–NOAA.
(*c*) Professor O. S. Madsen.

(*d*) Theoretical; applied research.
(*e*) From available data on the geometry of bed forms (ripples) generated on the sea floor by waves an empirical relationship between sediment characteristics, wave characteristics and ripple geometry will be sought. This empirical relationship will employ nondimensional parameters of physical significance to the problem of wave-sediment interaction. Employing the empirical relationship for ripple geometry the resulting dissipation of wave energy through bottom friction will be evaluated. Results will be compared with results obtained by the conventional procedure which does not account for the wave-sediment interaction but assumes a constant friction factor.

081-10952-220-00

BEDFORMS IN UNIDIRECTIONAL FLOW

(*c*) Professor O. S. Madsen.
(*d*) Theoretical; basic research (Doctoral theses).
(*e*) Analysis of the mechanics of the development of bedforms on a moveable bed in unidirectional flow with emphasis on ripple formation.
(*g*) The perturbation of the flow over a wavy boundary is analyzed based on a hydrodynamic model consisting of a viscous sublayer, a turbulent wall layer and inviscid outer flow region. The shear stress variation associated with the flow perturbations is evaluated from the hydrodynamic model using a turbulent eddy viscosity based on the mean bottom shear stress. The lag distance between crests of bottom bed forms and the points of maximum bottom shear is determined and show excellent agreement with published experimental data. The Meyer, Peter and Muller bedload formula is used to determine the stability of the wavy bed and growth rates of unstable bed forms are determined. Comparison of predicted ripple characteristics with experimental observations, available in the literature, will be performed.

081-10953-430-88

WAVE AND CURRENT STUDIES FOR OFFSHORE OIL DEVELOPMENT IN VENEZUELA

(*b*) Instituto Technologico Venezolano Del Petroleo, Caracas.
(*c*) Professor B. R. Pearce.
(*d*) Basic and applied research (Master's thesis).
(*e*) Assessment of design parameters for offshore oil towers making use of wave and current measurements and numerical models to hind-case extreme wind wave conditions.
(*g*) A parametric wind-sea model for the coastal region combining the effects on nonlinear energy exchange between wind-sea and swell is being developed. The importance of an accurate description of the wind field in conjunction with the wave model to describe the complex air-to-sea energy transfer mechanisms requires the development of a boundary-layer wind model. Hindcasted storms are compared to existing field data to assess the accuracy of the models and then to establish a statistical base of wave data to be used as design criteria for offshore towers. A second phase of the project will include the application of a current model and the analysis of storm tide data.

081-10954-880-00

THE EFFECTS OF UNCERTAIN INPUT DATA ON RESERVOIR ECOSYSTEM MODELS

(*c*) Professor K. D. Stolzenbach.
(*d*) Theoretical and applied research (Doctoral thesis).
(*e*) A reservoir ecosystem model is applied to an existing reservoir for which field data is available. The sensitivity of the model results to the model structure and to the input data characteristics is being investigated.
(*f*) Completed.
(*g*) The sensitivity analysis indicates a strong coupling between the structural assumptions of the model algorithms and the effect of input data on model results. Particularly important is the compatibility of spatial and temporal scales of variability between the model structure, the input data, and the desired application of the results.
(*h*) Effects of Data Variability and Model Structure in Reservoir Ecosystem Simulation, R. B. Brown, *MIT Ph.D. Thesis*, Dept. of Civil Engrg., June 1978.

081-10955-870-44

ANALYSIS OF OFFSHORE BRINE DISPOSAL

(*b*) Environmental Assessment Division, NOAA, U.S. Department of Commerce.
(*c*) Professor K. S. Stolzenbach.
(*d*) Applied research (Master's thesis).
(*e*) Study alternative locations and designs for offshore disposal of brine associated with the storage of oil in salt domes. The research will analyze a number of specific proposed sites and will include the prediction of the induced salinity distribution, the specification of discharge design parameters, and the design of post-operational monitoring surveys.
(*g*) Empirical information on negatively buoyant jets has been used to specify the designs of submerged diffusers. An analytical model of intermediate field buoyant spreading of the dense effluent has been developed and incorporated in the diffuser design. A transient far field pollutant transport model has been applied to predict the time-varying induced concentration distribution.
(*h*) **Design Criteria for Submerged Discharges of Dense Effluent,** S. S. Tong, *M.S. Thesis*, MIT, Dept. of Civil Engrg., June 1978.

081-10956-870-44

EVALUATION OF MIXING ZONE CHARACTERISTICS ASSOCIATED WITH OFFSHORE POLLUTANT DISPOSAL

(*b*) Environmental Assessment Division, NOAA, U.S. Department of Commerce.
(*c*) Professor K. D. Stolzenbach.
(*d*) Basic and applied research (Master's thesis).
(*e*) A transient pollutant transport model is used to investigate the sensitivity of offshore mixing zones to: (i) the characteristics of the pollutant and the discharge structure, (ii) site specific oceanographic parameters, and (iii) the definition of the mixing zone in terms of critical pollutant concentrations and exposure times.
(*f*) Completed.
(*g*) A second order autoregressive scheme has been used to characterize the nontidal time series of ocean currents. A generalized dimensionless framework for considering the induced concentrations has been developed.
(*h*) **Dispersion Zone Characteristics of Ocean Discharges,** D. R. Gaboury, *M.S. Thesis*, MIT, Dept. of Civil Engrg., Mar. 1978.

081-10957-880-00

NUTRIENT TRANSPORT BY SURFACE AND SUBSURFACE FLOW IN THE SALT MARSH ECOSYTEM

(*b*) MIT-WHOI Joint Program, Sea Grant–pending.
(*c*) Professor Harold Hemond, Professor Keith Stolzenbach, in cooperation with Dr. John Teal, Sr. Scientist, WHOI.
(*d*) Experimental and theoretical.
(*e*) Study of free-surface and subsurface flow phenomena in the salt marsh system, with emphasis on the role of water in nutrient exchanges with the estuary and the groundwater system.
(*g*) Instrumentation has been designed and built to measure infiltration rates as a function of time on the salt marsh surface. An infiltration study of the Great Sippewisset Marsh is currently underway.

081-10958-690-00

HEAT COLLECTION AND WITHDRAWAL IN SOLAR PONDS

(*b*) Ford Professorship.
(*c*) Professor D. R. F. Harleman, Dr. S. Bloss.
(*d*) Experimental and theoretical.
(*e*) Design and operation of a laboratory solar pond to investigate the influence of heat losses, the shape of the sta-

bilizing salinity gradient and the method of heat removal from the bottom layer on the efficiency of the pond.

(*g*) A solar pond is an inexpensive means to collect solar and atmospheric radiative energy to provide low-temperature heat for space-heating. Calculations have been carried out using a one-dimensional mathematical model to determine the governing parameters and their limiting values (i.e., depth of pond, bottom temperature, heat fluxes available at the bottom, etc.), which are necessary for the design of the laboratory pond and the subsequent applicability of laboratory results to field projects.

081-10959-870-00

EUTROPHICATION MODELS FOR LAKES: ANALYSIS OF HYDROTHERMAL-BIOCHEMICAL COUPLING

(*b*) Ford Professorship.
(*c*) Professor D. R. F. Harleman.
(*d*) Analytical; basic research (Ph.D. thesis).
(*e*) To provide a basic understanding of the coupling between hdyrothermal and biochemical components of lake eutrophication models. To improve the predictive capability of coupled eutrophication models by developing new component models and couplings designed to eliminate the influence of hydrothermal process modeling on nutrient cycle transformation rates.
(*g*) Current work includes the coupling of a wind mixing hydrothermal model and various biochemical models for the phosphorus cycle. Model will be tested against lake water quality data.
(*h*) **Summary Report of the IIASA Workshop on Geophysical and Ecological Modeling of Deep Lakes and Reservoirs,** S. E. Jdrgensen, D. R. F. Harleman, *WP-78-24, Intl. Inst. for Applied Systems Analysis*, Laxenburg, Austria, July 1978.

081-10960-340-52

WATER MANAGEMENT IN THE ELECTRIC POWER INDUSTRY: ISSUES OF WATER CONSUMPTION AND WATER QUALITY IN ALTERNATIVE CLOSED CYCLE COOLING SYSTEMS

(*b*) U.S. Dept. of Energy, Division of Environmental Control Technology.
(*c*) Professor D. R. F. Harleman, Dr. E. E. Adams, Dr. R. J. Barbera, Prof. M. Golay (Nuclear Engineering) and Dr. L. Glicksman (Mechanical Engineering).
(*d*) Theoretical research and assessments; applied research.
(*e*) Examine the use of cooling ponds and lakes as closed cycle cooling system alternatives to conventional forced or natural draft evaporative towers so as to increase the possibility of siting generating stations in water short areas. The implementation of these alternatives will require a careful analysis of water consumption in relation to water rights and consequent effects on water quality. The research will be interdisciplinary and will involve four parts: the first deals with the central water management issues of closed cycle cooling mode alternatives. The remaining three parts identify technical areas in which supporting research is needed in order to implement these alternatives. These include: (2) hydrothermal performance and water quality alterations of cooling ponds, lakes and reservoirs, (3) research on a unique wet/dry surface for cooling towers, and (4) cooling tower drift reduction.

081-10961-340-00

EVALUATION OF SUBMERGED DIFFUSERS FOR SHALLOW COASTAL ZONES

(*b*) Electric Power Program of the MIT Energy Laboratory.
(*c*) Dr. E. E. Adams and Professor D. R. F. Harleman.
(*d*) Theoretical and experimental; applied research (Master's thesis).
(*e*) Submerged diffusers are often used to dilute condenser cooling water from coastal power stations. At sites where the ambient current is predominately alongshore and reversing, a staged diffuser (in which nozzles are directed essentially offshore) is employed because of its symmetry and ability to intercept crossflow. Experimental and analytical studies of the near field of staged diffusers were made. The results were used to develop time-temperature relationships for entrained organisms. Comparisons of these relationships with corresponding ones for other diffuser types were carried out.
(*g*) Previous analysis has treated the staged diffuser as a line source of momentum in stagnant water. This analysis has been extended to study interaction among individual jets by solving for the jet trajectories as they respond to the flow field set up by adjacent jets and the ambient current. In addition, a potential flow model has been developed to determine the external flow field (and thus the origin of any passive organisms entrained in the plume) for cases of constant water depth and a linearly sloping bottom.

081-10962-340-75

EFFECTS OF PUMPED-STORAGE OPERATION ON RESERVOIR STRATIFICATION

(*b*) Charles T. Main of New York, Inc. and Power Authority of State of N.Y.
(*c*) Professor D. R. F. Harleman, Dr. E. E. Adams, and Dr. Siegfried Bloss.
(*d*) Applied research.
(*e*) Pumped storage power plants operate by pumping water from a lower reservoir to an upper reservoir during off-peak hours in electrical demand and then releasing the water for hydroelectric generation during peak hours. The effects of this cyclic operation on the annual temperature regimes of lower reservoirs is studied mathematically using the MIT Deep Reservoir Model. The proposed Prattsville Pumped Storage project in eastern New York is used as a case study.
(*g*) An analysis was made of the natural seasonal stratification cycle in the reservoir. Model predictions were found to compare well with field measurements. Calculations were then made for pumped-storage conditions. For these conditions the models suggest that the lower reservoir will still stratify, but the total heat content will be increased and the thermocline will be deeper. The model was also applied to the lower reservoir of a nearby existing pumped storage project. Calculated temperature profiles were shown to provide good agreement with measured data, and most significantly, to reproduce the observed well-mixed character of the reservoir.
(*h*) **Combined Use of Physical and Mathematical Models in Evaluating the Effects of Pumped Storage Operation on the Thermal Structure of a Reservoir,** D. N. Brocard, E. E. Adams, S. Bloss, presented *Intl. Symp. on Environmental Effects of Hydraulic Engrg. Works*, Knoxville, Tenn., Sept. 12-14, 1978.

081-10963-860-00

DEMAND MODELING IN WATER RESOURCE PLANNING

(*c*) Professor David H. Marks.
(*d*) Applied research.
(*e*) Demand modeling based on disaggregation assumptions is investigated to further understand water sector demand response to economic policies, conservation strategies, and water use technology changes.
(*g*) Development stage.

081-10964-870-80

PLANNING FOR NONPOINT SOURCE WATER QUALITY IMPACTS OF REGIONAL DEVELOPMENT

(*b*) Rockefeller Foundation–MIT Environmental Impact Assessment Project.
(*c*) Professor D. H. Marks.
(*d*) Applied research.
(*e*) Methodologies for integrating quantitative modeling and cost effective control measure evaluation for runoff related water quality problems in developing areas.
(*g*) Development and implementation of a normative model of nonpoint source pollution control planning. Work will be

addressed toward integrating the increasingly more detailed levels of planning necessary to respond to the questions of where nonpoint source pollution occurs, where and to what extent it should be controlled, and how the specific controls should be designed. Information transfers between levels of planning and the specific activities undertaken at each level will be specified. The normative model will be compared to present U.S. planning practices to identify specific changes which should be made to make nonpoint source planning more effective and efficient.

(*h*) **Planning Methods for Regional Nonpoint Source Pollution Control,** R. R. Noss, *M.S. Thesis*, MIT, Jan. 1978.
Implementation of Section 208 of the Federal Water Pollution Control Act, T. P. Lustig, *Ph.D. Thesis*, MIT, Mar. 1978.

081-10965-860-52

MULTIOBJECTIVE PLANNING FOR ENERGY/WATER RESOURCE TRADEOFFS IN THE YELLOWSTONE RIVER BASIN, WYOMING AND MONTANA

(*b*) U.S. Energy Research and Development Administration (ERDA).
(*c*) Professor D. H. Marks.
(*d*) Applied research.
(*e*) A model to assist in the evaluation of alternative water supply strategies for energy facilities in arid areas is under development. The various institutional factors are linked to hydrologic considerations in a manner to permit multiobjective optimization. A case study is performed on the Powder River near Gillette, Wyoming in the Yellowstone River Basin.
(*g*) Model development.
(*h*) **Water Supply for Western Energy Development: A Planning Methodology and Institutional Evaluation,** J. H. Gerstle, *SMCE Thesis*, Dept. of Civil Engrg., MIT, 1978.
A Procedure for Water Rights Evaluation with Applications to Western Energy Development, J. H. Gerstle, R. J. Barbera, D. H. Marks, *AWRA Natl. Conf.*, Orlando, Fla., Nov. 1978.
A Water Rights Transfer Model with Consideration of Hydrologic and Institutional Factors, J. H. Gerstle, D. H. Marks, R. J. Barbera, presented *ASCE Water Resource Systems Specialty Conf.*, Houston, Tex., Feb. 1979.

081-10966-870-80

COMPREHENSIVE PLANNING FOR HAZARDOUS AND TOXIC WASTE MANAGEMENT IN MASSACHUSETTS

(*b*) Ford Foundation.
(*c*) Professor D. H. Marks.
(*d*) Applied research (Master's thesis).
(*e*) Study of the present pattern of generation and disposal of hazardous wastes in Massachusetts. Determination of critical problems in the development of a management plan and assessment of appropriate planning methods for dealing with these (systems analysis, decision analysis, heuristic approaches, planning processes, etc.).
(*g*) Types, quantities and effects of potentially hazardous wastes examined. Appropriate legislation and relevant organizations identified and investigated. Detailed case study on metal-finishing industries carried out to provide base data for evaluation of planning approaches, and to identify problem areas.
(*h*) **Working Paper No. 1: Problem Identification,** D. Hanrahan, J. Rhodes,, Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, Dept. of Civil Engrg., MIT, May 1978.
Working Paper No. 2: Progress Report on First Case Study, D. Hanrahan, J. Rhodes, C. McHugh, D. H. Marks, Ralph M. Parsons Lab. Dept. of Civil Engrg., MIT, July 1978. MIT, July 1978.

081-10967-840-56

NILE DELTA IRRIGATION PLANNING EGYPTIAN WATER MASTER PLAN

(*b*) U.S. AID–MIT Technology Adaptation Program.
(*c*) Professor D. H. Marks, Dr. D. S. Grossman.
(*d*) Applied research.
(*e*) Models to aid in the long range plan for expansion of agricultural development in the Nile Delta. Aspects to be studied are changes in the supply and drainage networks, reclamation of new lands and groundwater use.
(*g*) Model development.
(*h*) **Water Irrigation Distribution Planning in the Nile River Delta,** F. Ramos, D. H. Marks, presented *ASCE Specialty Conf. on Water Resource Systems*, Houston, Tex., Feb. 1978.

081-10968-840-56

MULTI-LEVEL AGRICULTURAL PLANNING EGYPTIAN WATER MASTER PLAN

(*b*) U.S. AID–MIT Technology Adaptation Program.
(*c*) Professor D. H. Marks, Dr. D. S. Grossman.
(*d*) Applied research.
(*e*) The multi-level approach to drainage planning in Egypt is analyzed. The project focuses on mathematical models as tools to aid decisions at each planning level as well as the interactions that take place between levels during the design process.
(*g*) Model development.
(*h*) **Multi-Level Planning for Agricultural Drainage in the Nile Valley,** K. M. Strzepek, D. H. Marks, presented *ASCE Specialty Conf. on Water Resource Systems*, Houston, Tex., Feb. 1978.

081-10969-350-56

HIGH ASWAN DAM OPERATIONAL STUDY EGYPTIAN WATER MASTER PLAN

(*b*) U.S. AID–MIT Technology Adaptation Program.
(*c*) Professor D. H. Marks, Dr. D. S. Grossman.
(*d*) Applied research.
(*e*) Operational questions at the High Aswan Dam will be studied using simulation and omptimization models. Conflicts between the use of water for irrigation supply, electric power generation, and flood control will be modeled to aid decision makers in their resolution.
(*g*) Model develpment.
(*h*) **A Guide for the Use of the MIT River Basin Simulation Model,** K. M. Strzepek, R. L. Lenton, D. H. Marks, Technology Adaptation Program, Report MIT, Oct. 1978.

081-10970-880-54

DYNAMIC LAND-SURFACE BOUNDARY CONDITION FOR CLIMATE MODELING

(*b*) National Science Foundation.
(*c*) Professor P. S. Eagleson.
(*d*) Theoretical; basic research.
(*e*) The flux of heat and of water mass through the interface of an atmosphere-soil-vegetal system is modeled one-dimensionally. The model is tested for sensitivity and frequency response in order to define a hierarchy of dynamic land surface boundary conditions for use in the comparable set of climate modeling problems.

081-10971-810-50

INFERENCE OF EFFECTIVE SOIL PROPERTIES FROM OBSERVED VEGETAL CANOPY DENSITY

(*b*) NASA (Goddard Space Flight Center).
(*c*) Professor P. S. Eagleson.
(*d*) Theoretical/experimental; basic research.
(*e*) An equilibrium hypothesis for the density of natural vegetation will be evaluated with respect to its utility in inferring the areal average effective soil parameters of catchments. This has the potential for improving the land surface boundary condition in numerical climate models

through the introduction of more realistic soil moisture dynamics.

081-10972-820-44

SEA WATER INTRUSION IN OFFSHORE ISLANDS

(*b*) Sea Grant Office of the National Oceanic and Atmospheric Agency.
(*c*) Professor J. L. Wilson.
(*d*) Applied research (Master's and Doctoral theses).
(*e*) A finite element model is being developed to study sea water intrusion under offshore islands and along irregular coastlines. The model is based on a two-dimensional plan view of intrusion, assuming a sharp interface between fresh and saltwater. Special boundary condition problems are being investigated, especially in the vicinity of the freshwater outlet to the sea and near the toe of the saltwater wedge.
(*g*) The model has been formulated and is currently being encoded and tested.
(*h*) Comments on **A Mathematical Model of Stratified Groundwater Flow,** by N. Rofait, *Hydrologic Sciences Bulletin* **23,** 2, Sept. 1978, A. Sa da Costa, J. L. Wilson.
Derivation of Governing Equations for a Two-Layer Model of Saltwater Intrusion, A. Sa da Costa, J. L. Wilson, *Working Paper 1, Sea Water Intrusion in Offshore Islands, OSP 85454*, MIT Dept. of Civil Engrg., Sept. 1978.

081-10973-820-56

NILE DELTA GROUNDWATER STUDY

(*b*) Agency for International Development through MIT-Cairo University Joint Technological Planning Program.
(*c*) Professor J. L. Wilson.
(*d*) Applied research (Master's and Doctoral theses).
(*e*) Numerical and analytical models for the prediction of piezometric heat and seawater intrusion in the Nile Delta aquifer of Egypt are prime objectives of this research. The models will be used to evaluate aquifer safe yield, cyclic storage capability and the interaction with irrigation and drainage.
(*g*) An existing numerical model of aquifer hydraulics, AQUIFRM, has been improved and applied to analysis of the Delta Aquifer. Also several simple analytical models of sea water intrusion were developed and applied. These models are being used to make a preliminary evaluation of aquifer response to various management schemes for drainage control, water storage and water supply. A new finite-element sea water intrusion model currently under development, will be applied to the continuing evaluation of this aquifer.

081-10974-820-56

A UNIFIED APPROACH TO GROUNDWATER MODELING

(*b*) Agency for International Development through the MIT-Cairo University Joint Technological Planning Program.
(*c*) Professor J. L. Wilson.
(*d*) Theoretical; basic and applied research (Master's and Doctoral theses).
(*e*) Assessment of existing parameter and state estimation methods for groundwater flow models. First order sensitivity analysis of estimators. Development of state-space forms of the model and explicit and implicit solutions convenient for parameter estimation, sensitivity analysis, groundwater management applications, etc.
(*g*) A comprehensive review of the state of the art revealed a lack of unification and unsatisfactory performance of applied methods. A new and unified approach in a Bayesian framework has been developed and applied. The results obtained indicate that since in most real-world cases the estimation of state and parameters takes place from effectively small samples, and in some cases from nonuniform data, it is necessary to use prior information about the state and parameters, combined in an optimal way with information obtained from the data.
(*h*) **Steady State vs. Transient Parameter Estimation in Groundwater Systems,** J. L. Wilson, M. Dettinger, *Proc. ASCE Hydraulics Div. Specialty Conf. Verification of Math. and Physical Models in Hydraulic Engrg.*, Aug. 1978.
State and Parameter Estimation in Groundwater Models, J. L. Wilson, P. Kitanidis, M. Dettinger, *Proc. AGU Chapman Conf. Applications of Kalman Filter to Hydrology, Hydraulics and Water Resources*, May 1978.

081-10975-810-33

THE DESIGN OF OPTIMUM DATA COLLECTION NETWORKS TO ESTIMATE THE TIME AVERAGED AREAL MEAN OF PRECIPITATION IN PUERTO RICO

(*b*) Office of Water Research and Technology, Dept. of the Interior through the Water Resources Research Institute, University of Puerto Rico.
(*c*) Professor R. L. Bras.
(*d*) Theoretical; applied research.
(*e*) Development of the theoretical framework to evaluate the accuracy of raingage networks used to estimate the time averaged areal mean of precipitation. Estimation theory concepts are used.
(*f*) Completed.
(*g*) A methodology and associated computer program is available to evaluate the accuracy of any given network in terms of a number of stations, location, length of observation and measurement error.
(*h*) **Time Averaged Areal Mean of Precipitation: Estimation and Network Design,** R. L. Bras, R. Colon, *Water Resources Research* **14,** 5, Oct. 1978.
Time Averaged Areal Mean of Precipitation: Estimation and Network Design, R. L. Bras, R. Colon, Univ. of Puerto Rico, Water Research Inst., Feb. 1977.
Network Design for Precipitation Areal Average Estimation, R. L. Bras, presented *Intl. Seminar in Hydrology and Water Resources*, Simon Bolivar Univ., Caracas, Venezuela, Mar. 1978.
Sampling Network Design in Hydrology and Water Quality: A Review of Linear Estimation Theory Applications, R. L. Bras, *Proc. Amer. Geophys. Union Chapman Conf. Applications of Kalman Filter Hydrology, Hydraulics and Water Resources*, Pittsburgh, May 1978.

081-10976-810-54

SEARCH OF THEORETICAL MODELS OF HYDROLOGIC PARAMETERS USING DERIVED DISTRIBUTION TECHNIQUES

(*b*) National Science Foundation.
(*c*) Professor R. L. Bras.
(*d*) Theoretical; applied research.
(*e*) This work will attempt to derive theoretical probability density distributions for hydrologic parameters like the volume of water above a certain threshold discharge rate resulting from runoff. The obtained p.d.f. should be based on easily available physical basin characteristics and applicable to any region without extensive availability of data.
(*g*) The theoretical p.d.f. for the volume of water above a given threshold in urban areas where overland flow dominates has been derived using the kinematic wave equations as a physical model. A similar approach is being carried on with unit hydrograph concepts with model parameters related to basin characteristics.
(*h*) **Derived Distribution of Water Volume Above a Given Threshold Discharge,** S. Chan, R. L. Bras, *T.R. No. 234*, R. M. Parsons Lab. of Water Resources and Hydrodynamics, MIT, May 1978.
Theoretical Models of Hydrologic Parameters Using Derived Distribution Techniques, R. L. Bras, S. Chan,, *Proc. Intl. Symp. Risk and Reliability in Water Resources*, Univ. of Waterloo, Ontario, Canada, June 1978.
Urban Storm Water Management: Distribution of Flood Volumes, S. Chan, R. L. Bras, *Water Resources Research*, 1978.

081-10977-300-56

STOCHASTIC MODELS OF NILE INFLOWS TO LAKE NASSER

(*b*) Agency of International Development through the MIT Technology Adaptation Program.
(*c*) Professor R. L. Bras and Professor P. S. Eagleson.
(*d*) Applied and theoretical research.
(*e*) Stochastic models of river flows into Lake Nasser were developed and implemented. These are being used in frequency analysis studies and in reservoir and irrigation systems operation studies. Forecasting models of river flow, leading to better control of water works are being studied. The water balance of swampy regions of the White Nile is also a topic of research. The goal is to obtain improved understanding of the changes in the statistics of their water yield resulting from proposed drainage and reclamation projects.
(*g*) Three different stochastic models which preserve historical statistics of the Nile River have been implemented at MIT and Cairo University. The next phase of the study will use these models in systems simulation work. During the next few years detailed physical modeling of the White Nile region in the Sudan will be attempted. All work will be leading to an on-line real time streamflow forecasting capability for Egypt. A preliminary water balance has been performed for one catchment tributary to the Bahr El Ghazal river basin in the White Nile.
(*h*) **Theory and Applications of the Multivariate Broken Line, Disaggregation and Monthly Autoregressive Stream Flow Generators to the Nile River,** K. Curry, R. L. Bras, *Technology Adaptation Program Rept. No. 78-5*, MIT, Sept. 1978.

081-10978-840-00

ON-LINE CONTROL OF IRRIGATION SYSTEMS

(*c*) Professor R. L. Bras.
(*d*) Theoretical; applied research.
(*e*) Estimation, forecasting and derived distribution techniques are used to account for the stochastic behavior of rainfall and runoff and their effect on soil moisture. This information is used to obtain optimal irrigation schedules and maximize crop yield.

081-10979-340-00

ESTIMATION AND PREDICTION TECHNIQUES IN SHORT TERM FORECAST OF METEOROLOGICAL CONDITIONS IMPORTANT TO POWER PLANT OPERATION

(*b*) MIT Energy Laboratory.
(*c*) Professor R. L. Bras and Professor K. D. Stolzenbach.
(*d*) Theoretical; applied research.
(*e*) Estimation techniques are to be used to improve existing, localized, forecasts of meteorological variables that affect power plant operation through influences in cooling systems behavior.
(*g*) A program implementing the philosophy of regression using Group Method of Data Handling is being developed. The technique will be used to obtain weather prediction models to be compared with existing National Weather Services methodologies.

081-10980-650-00

PROBABILISTIC METHODS OF MINERAL EXPLORATION

(*c*) Professor R. L. Bras and D. Venceziano.
(*d*) Theoretical; applied research.
(*e*) Methodologies for spatial sampling and estimation of mineral reserves are being studied. Sampling goals are to define exploitable regions and estimate total reserves within the region as accurately and reliably as possible.

081-10981-810-00

OPTIMAL ESTIMATION OF MEAN AREAL PRECIPITATION IN AREAS OF OROGRAPHIC INFLUENCES

(*c*) Professor R. L. Bras.
(*d*) Theoretical; applied research.
(*e*) Modern statistical methodologies for estimating random fields from point observations are being used to design raingage networks that will maximize information content in areas of strong orographic influence. Universal kreging, or optimal linear least square estimator, is the technique utilized.

081-10982-870-44

CHEMICAL AND BIOLOGICAL FACTORS AFFECTING THE INITIATION, DEVELOPMENT AND SPREADING OF NEW ENGLAND RED TIDES

(*b*) Sea Grant Office–NOAA, International Copper Research Association.
(*c*) Professor F. M. M. Morel.
(*d*) Fundamental and applied research.
(*e*) The role of trace metal chelation, particularly that of copper in controlling and triggering blooms of the toxic dinoflagellate, *Gonvaulax tamarensis*, is being systematically investigated. In addition, particular aspects of the organism's life cycle are being examined to determine how revival of the dormant, benthic stage (cyst) functions in the bloom initiation process.
(*g*) Concentrations of cupric ion that are toxic to the red tide organism have been determined in laboratory batch cultures and compared with results for other algal species. Natural populations of dormant cysts have been germinated under various chemical and physical conditions and the critical parameters for the inducement of germination determined.
(*h*) **Chemical and Biological Characteristics Affecting the Initiation, Development, and Distribution of Toxic Dinoflagellate Blooms in New England,** D. M. Anderson, Dec. 1977. *Ph.D. Thesis*, Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, Mass. Inst. of Tech., Cambridge, Mass.
The Potential Importance of Benthic Cysts of ***Gonyaulax tamarensis*** **and** ***Gonyaulax excavata*** **in Initiating Toxic Dinoflagellate Blooms in the Cape Cod Region,** D. M. Anderson, D. Wall, *J. Phycology*, 1978.
The Seeding of Two Red Tide Blooms by the Germination of Benthic ***Gonyaulax tamarensis*** **Hypnocysts,** D. M. Anderson, F. M. M. Morel, *Estuarine and Coastal Marine Sciences*, 1978.

081-10983-870-54

MODELING OF LAKE RESPONSE TO NUTRIENT LOADINGS

(*b*) NSF Fellowship.
(*c*) Professor F. M. M. Morel.
(*d*) Theoretical; basic and applied research.
(*e*) This project has examined models that predict trophic state for given phosphorus loadings and models of process which control the distribution of phosphorus in lakes.
(*f*) Completed.
(*g*) A stepwise discriminant analysis of 128 P. limited lake has given insight into the meaning of loading diagrams and into the necessary functionalities for phosphorous removal terms. On this basis, a simple steady state lake model has been proposed whose prediction reliability is shown to be comparable to that of models requiring *a posteriori* evaluation of phosphorus loss. An algorithm for the computation of vertical mixing across the thermocline has been developed, as has a model for the adsorption of phosphate on iron and aluminium oxides.
(*h*) **The Modeling of Lake Responses to Phosphorus Loadings: Empirical, Chemical, and Hydrodynamic Aspects,** J. G. Yeasted, Feb. 1978. *Ph.D. Thesis*, Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, Mass. Inst. of Tech., Cambridge, Mass.
On the Interfacing of Chemical, Physical and Biological Water Quality Models, F. M. M. Morel, J. G. Yeasted, in: **Fate of Pollutants in the Air and Water Environment,** I. H. Suffet, ed., Wiley-Interscience, 1977.
Empirical Insights into Lake Response to Nutrient Loadings, with Application to Models of Phosphorus in

Lakes, J. G. Yeasted, F. M. M. Morel, *Environmental Science and Technology* **12**, 195, Feb. 1978.

081-10984-870-54

TRACE METAL AND PHYTOPLANTON INTERACTIONS

(*b*) National Science Foundation.
(*c*) Professor F. M. M. Morel.
(*d*) Fundamental research.
(*e*) The interactions between trace metals and various species of freshwater and marine phytoplankton are being studied systematically. The availability and/or toxicity of some metals such as iron, copper or zinc are presumed to be important factors in controlling algal growth and determining the dominant plankton species. The role that organic ligands–either exuded by the cells or from external sources–play in controlling the biological availability and toxicity of trace metals is being assessed. The effect of metal toxicity on nutrient (N, P, Si) uptake and cell division are investigated as the principal mechanisms by which metals inhibit the growth of various species and influence phytoplankton speciation and ecology.
(*g*) Large differences in the sensitivity of various species of phytoplankton to cupric ion activity have been demonstrated. A particular response of some marine diatoms to toxicity has been observed as an adaptive lag phase (with no apparent conditioning of the medium). A strong antagonism between cupric ion activity and silicic acid concentration has been demonstrated and is being characterized. The production of significant quantities of copper and iron complexing metabolites by freshwater blue green algae has been quantified by potentiometric techniques. The availability and toxicity of several metals for a variety of phytoplankton species have been quantified. In particular, it has been demonstrated that growth rate can be limited by the availability of zinc which is controlled by the zinc ion activity.
(*h*) **Potentiometric Determination of Copper Complexation by Extracellular Organic Compounds from Phytoplankton,** D. M. McKnight, May 1978. *Masters of Science Thesis*, Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, Mass. Inst. of Tech., Cambridge, Mass.
Growth Limitation of a Coastal Diatom by Low Zinc Ion Activity, M. A. Anderson, F. M. M. Morel, R. R. L. Guillard, *Nature*, 1978.
AQUIL: A Chemically Defined Phytoplankton Culture Medium for Trace Metal Studies, F. M. M. Morel, J. G. Rueter, D. M. Anderson, R. R. L. Guillard, *J. Phycology*, 1978.
Chemical Aspects of Trace Metal Toxicity to Phytoplankton, F. M. M. Morel, N. M. L. Morel, D. M. Anderson, D. M. McKnight, J. G. Rueter, Jr., in: *The State of Marine Environmental Research*, 1978.
Potentiometric Determination of Copper Complexation by Phytoplankton Exudates, K. C. Swallow, D. M. McKnight, J. C. Westall, N. M. L. Morel, F. M. M. Morel, *Limnology and Oceanography*, 1978.
Copper Toxicity to ***Skeletonema costatum*** **(Bacillariophyceae),** N. M. L. Morel, J. G. Rueter, F. M. M. Morel, *J. Phycology*, 1978.

081-10985-880-54

BIOGEOCHEMISTRY AND ECOLOGY OF FRESHWATER WETLANDS

(*b*) National Science Foundation–Pending.
(*c*) Professor H. F. Hemond.
(*d*) Experimental and theoretical.
(*e*) Investigation of the hydrological, chemical and biological phenomena which determine the physical structure, chemical environment, and biological communities of freshwater wetlands. Present focus is on the input/output fluxes and internal transformations of the nitrogen budget.
(*g*) Recent work indicates that 15_N tracer studies are an appropriate tool for elucidating internal nitrogen transformations. Nitrogen deposition rates in an ombrotropic bog are sufficiently high to suggest that direct absorption of atmospheric NH_3 may be a significant process in some bogs.
(*h*) **Biogeochemistry of Thoreau's Bog, Concord, Massachusetts,** H. F. Hemond, *Ecological Monographs*,, 1978.

081-10986-870-00

ACCUMULATION OF SILICON BY NON-SILICIFIED MARINE ALGAE

(*b*) Edgerton Assistant Professorship.
(*c*) Professor W. W. Chisholm (MIT) and Dr. R. R. L. Guillard (WHOI).
(*d*) Basic research and experimental.
(*e*) Nonsilicon-requiring species were examined for their ability to accumulate significant amounts of silicic-acid from artificial culturing media. This phenomenon has never been described, and could play a key role in the competition between diatoms (which require silicon) and other phytoplankton groups in areas of the oceans where silicon is in short supply.
(*f*) Completed.
(*g*) Many species were found to accumulate amounts of silicon comparable to those found in diatoms. Uptake by one species, *Platymonas* sp. was examined in detail and found to be related to the growth rate and the $Si(OH)_4$ concentration in the medium.
(*h*) **Marine Alga** ***Platymonas*** **sp. Accumulate Silicon Without Apparent Requirement,** J. A. Fuhrman, S. W. Chisholm, R. R. L. Guillard, *Nature 272:244-246*, 1978.

081-10987-690-70

BIOCONVERSION: LIPID-RICH ALGAE AS A RENEWABLE SOURCE OF CONVENTIONAL LIQUID FUELS

(*b*) Exxon Research and Engineering Company.
(*c*) Professor S. W. Chisholm.
(*d*) Experimental and applied.
(*e*) Laboratory examination of conditions stimulating lipid metabolism in algae and extraction of these products for subsequent conversion to petro-fuels. Experiments will be performed to determine optimal environmental conditions for lipid production, and feasible conditions for large scale operations. Nutrients and physical conditions are being investigated.
(*g*) Some phytoplankton species can produce up to 80 percent lipid (dry weight basis) when subjected to certain growth conditions. Factors such as light, nutrients and temperature can either enhance or hinder this production. A systematic investigation of these factors is underway to define feasible and optimum conditions that would maximize lipid production on a mass-culture scale. The lipid product is a highly reduced mixture of long chain organics and thus similar to petroleum and refinable by conventional methods.

081-10988-890-00

SILICIC ACID POOL SIZES AND THE GROWTH OF MARINE DIATOMS

(*b*) Edgerton Assistant Professorship.
(*c*) Professor S. W. Chisholm.
(*d*) Basic research and experimental.
(*e*) All diatoms require silicon for growth. Silicic acid is taken up by the cells and polymerized into a rigid frustule made of amorphous silicon. The mechanism of polymerization is unknown. This study focuses on the size of the dissolved silicic acid pool inside the cells which reflects an intermediary step between transport and deposition. The pool sizes are being studied under various growth conditions to try to elucidate any regulatory role this pool might play in the growth of these species.
(*g*) The size of the soluble intracellular pool of silicic acid in the marine diatom *Thalassiosira fluviatilis* has been found to vary with growth conditions and degree of silicon starvation. Preliminary results suggest that it can represent up to 30 percent of the total silicon per cell in some cases. This contrasts with the established notion that the dissolved pool represents only a small fraction of the total cellular silicon.

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UNIVERSITY OF MASSACHUSETTS, School of Engineering, Amherst, Mass. 01003. Dr. Russel C. Jones, Dean.

082-11706-430-00

RESPONSE OF LABORATORY BREAKWATERS

(*c*) Dr. Charles E. Carver, Jr., Paul A. Palo, Department of Civil Engineering.
(*d*) Experimental; applied research, M.S. thesis.
(*e*) Experiments conducted in a wind-wave flume to measure wave attenuation downstream of a resonant harbor subjected to wind-generated wave spectra.
(*f*) Completed.
(*g*) Fifty percent reduction in wave energy was observed in some cases; an approximate design chart for resonant breakwaters is presented and a resonator response function developed.
(*h*) **Analysis of an Exposed Reef Edge Harbor and Resonant Breakwater for an Ocean Thermal Power Plant at Palmyra,** P. A. Palo, *M.S. Thesis*, Dept. of Civil Engrg., Univ. Massachusetts.
Response of Laboratory Resonant Breakwaters, P. A. Palo, C. E. Carver, Jr., *Proc. ASCE Coastal Structures 79 Conference* **1**, pp. 174-193, Mar. 14-16, 1977.

082-11707-220-54

BED LOAD MEASUREMENTS AND MODELS

(*b*) National Science Foundation.
(*c*) Dr. Peter J. Murphy, Dept. of Civil Engineering.
(*d*) Experimental and theoretical; basic and applied.
(*e*) Develop an experimental technique for the measurement of bed load discharge in rivers. The technique is used to evaluate bed load formulas and to study the basic difference between bed load and suspended load in the region near the stream bed.
(*g*) To date the technique has been developed and tested in shallow streams. Bed load formulas are currently being evaluated. A new definition of bed load has been proposed.
(*h*) **Compartmented Sediment Trap,** P. J. Murphy, M. F. Amin, *J. Hydraulics Division, ASCE* **105**, HY5, pp. 489-500, May 1979.

082-11708-440-80

TURBULENCE MEASUREMENTS IN A LAKE

(*b*) The Engineering Foundation.
(*c*) Dr. Peter J. Murphy, Department of Civil Engineering.
(*d*) Experimental; basic and applied.
(*e*) Develop a measurement technique for the vertical heat flux due to turbulent mixing. A hot-film anemometer and a resistance thermometer are used to examine small scale turbulence that is typical of this heat transfer process.
(*f*) Completed.
(*g*) The equipment developed permitted the detection and measurement of w'T'. The averaging of the basic signal was insufficient due to the need for spacial resolution.
(*h*) **Turbulence Measurements in a Lake,** B. Brumley, P. J. Murphy, *Proc. 5th Biennial Symp. Turbulence*, Rolla, Missouri, 1977.

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MECHANICAL TECHNOLOGY INCORPORATED, Research and Development Division, 968 Albany-Shaker Road, Latham, N.Y. 12110. C. Boyajian, Vice President and General Manager, Research and Development Division.

083-10574-130-52

PARTICLE SEPARATION FROM GAS STREAM BY CENTRIFUGING

(*b*) DOE–Division of Fossil Energy Research.
(*c*) J. T. McCabe, Project Manager.
(*d*) A theoretical study to determine the feasibility of particle separation from a gas by a concept called a Cyclocentrifuge.
(*e*) Determine the effectiveness and economic advantage of employing centrifuges for gas particulate clean-up in processes relating to coal conversion and utilization. A theoretical aerodynamic analysis was made covering the blading characteristics required to impart the necessary swirl to the air to separate out dust particles in a reasonable path length, achieving zero exit swirl velocity.
(*f*) Phase I–Feasibility Study and Phase II–Model testing and demonstration have been completed. Phase III–Gasification Pilot Plant testing not yet started.
(*g*) Gas cleanup was determined to be an area in which the special characteristics of modified centrifuge offered technical and economic advantages over existing approaches. A new concept, called a Cyclocentrifuge, was evolved during the study which combined the best gas cleanup features of cyclones and centrifuges in a compact design capable of separating fine particulate matter from hot gas at large flow rates. A design example showed the Cyclocentrifuge to be capable of achieving a purity of 1 ppm of solids with a nominal maximum particle diameter of one micron when processing low Btu fuel from a coal gasifier.
(*h*) *MTI Tech. Rept. MTI 77R34*, available Tech. Info. Center, Special Asst. for Reproduction and Processing, U.S. ERDA, P.O. Box 62, Oak Ridge, Tenn. 37830.

083-10575-630-20

RESEARCH PROGRAM ON HELIUM FLOW IN CLOSED CYCLE GAS TURBINES

(*b*) Office of Naval Research.
(*c*) Thomas J. Ivsan, Project Engineer.
(*d*) An experimental program to determine the factors affecting the performance of axial flow compressor stages using helium gas as contrasted to air. The study includes the performance of suitable helium gas lubricated bearings.
(*e*) Project is concerned with two facets of component development for a closed-cycle gas turbine powerplant. One task is to experimentally evaluate a high-reaction axial compressor using helium gas to determine the effects of gas characteristics different from air. The second task is to analytically and experimentally evaluate support of the rotor on bearings lubricated by the helium.
(*f*) Analysis and test facility preparation has been completed, and single stage axial compressor tests are underway.
(*g*) The project will evaluate helium gas flow through both single and multistage axial compressors. The end objective is to determine axial compressor characteristics with helium gas and to supplement the compressor design procedure by test results. The gas bearing development will address those problems incurred in the design of gas film bearings for the gas turbine powerplant, i.e., shock and vibrations conditions under test evaluations which will extend steady state design theory by including dynamic effects.

083-10989-690-22

MATERIALS STUDY FOR HIGH PRESSURE SEAWATER HYDRAULIC TOOL MOTORS

(*b*) Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, Calif.
(*c*) Standley Gray, Program Manager; Bharat Bhushan, Senior Engineering Scientist.
(*d*) An experimental materials-seawater lubrication study of simulated critical load points in seawater powered hydraulic motor designs suitable for underwater tools.
(*e*) A comprehensive materials study was made for compact positive displacement hydraulic motors suitable for underwater tools using pressurized seawater to both power and lubricate the motor. As part of the study and using a baseline motor size of 5.8 HP input, the designs of three motor types–gear, vane and piston were analyzed to determine material operating conditions which should be used in simulated material tests in synthetic seawater. A literature survey, corrosion tests and wear tests of selected

material combinations under reciprocating and continuous sliding motions were performed at conditions up to 2000 psi loading and 1500 fpm velocity. Recommendations were made of best material combinations and motor types.

(*f*) The program was completed in April 1978.

(*g*) Particularly successful material combinations from the testing were Torlon 4301 (Polyamide-imide with fillers) versus Inco 625 and high purity alumina versus plasma sprayed tungsten carbide. In an overall assessment of motor types the double entry vane motor received top ranking and was recommended for development because of internal load balancing, self adjustment potential for wear and material compatibility, followed by the double row, axial piston multi-lobe cam design as second choice.

(*h*) **Materials Study for High Pressure Seawater Hydraulic Tool Motors,** B. Bhushan, S. Gray, *Final Report on Contract N68305-77-C-0001*, Civil Engrg. Lab., Naval Construction Battalion Center, Port Hueneme, Calif.

Investigation of Material Combinations Under High Load and Speed in Synthetic Seawater, B. Bhushan, S. Gray, *ASLE Preprint No. 78-LC-SC-1*, Oct. 24, 1978.

083-10990-620-45

RESEARCH ON PROPULSION BEARINGS AND SEALS FOR HIGH PERFORMANCE MERCHANT SHIPS

(*b*) Office of Advanced Ship Development Maritime Administration, U.S. Department of Commerce, Washington, D.C. 20230.

(*c*) Leo W. Winn, Program Manager.

(*d*) This project is classified as a combination of field investigation, experimental and applied research. It encompasses also the design and development of advanced stern tube bearings and seals. This program is directed toward accomplishing research on and developing new and improved propulsion shaft bearings and seals (emphasizing oil/water lubricated stern tube bearings and seals) for high performance merchant ships. In the first phase of this program which was completed on September 27, 1978, the state of art within the stern tube bearing and seal areas was established, the problems associated with the seals and bearings were defined and their economical value determined. Computer codes were generated and/or adopted to permit the design of new and improved components. At the end of Phase I layouts were made which defined the test vehicles and instrumentations to be employed in the forthcoming design and test verification work. Phase II of this program which forms the subject of the series of monthly reports commencing with No. 22 has begun on October 1, 1978. This phases consists of six parts: Part 1–Evaluation of Seal and Bearing Materials, Part 2–Fabrication and Assembly of Seal Test Vehicle, Part 3–Fabrication and Assembly of Bearing Test Vehicle, Part 4–Testing and Evaluation of Seals, Part 5–Testing and Evaluation of Bearings, and Part 6–Reports. The work outlined for Phase II is to be accomplished over a period of two years through October 1, 1980.

(*g*) Up to date results are summarized in the following reports (h) which can be obtained from the Office of Advanced Ship Development, Washington, D.C.

(*h*) **Bearing and Seal Materials for Stern Tube Applications–Assessment of the State-of-the-Art,** S. F. Murray, W. V. Smith, *Report No. MA-RD-920-77090*, June 1977.

Design and Operation of Stern Tube Bearings: An Assessment of the State-of-the-Art, O. Pinkus, *Report No. MA-RD-920-78010*, Sept. 1977.

Analysis and Design of Advanced Stern-Tube Bearing Systems, O. Pinkus, *Report No. MA-RD-920-79009*, Nov. 1978

Design and Operation of Stern-Tube Seals: An Assessment of the State-of-the-Art, L. Winn, O. Pinkus, *Report No. MA-RD-920-79013*, Dec. 1978.

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MICHIGAN STATE UNIVERSITY, College of Engineering, Department of Civil Engineering, East Lansing, Mich. 48824. Dr. William C. Taylor, Chairman.

084-08777-210-54

THE EFFECT OF RELEASED GASES ON HYDRAULIC TRANSIENTS

(*b*) National Science Foundation.

(*c*) David C. Wiggert, Assoc. Professor.

(*d*) Experimental and applied numerical research including Master's thesis.

(*e*) Investigation of hydraulic transient response with gas released from liquid in a long pipeline. Includes experimental study with gaseous cavitation in a pipe loop, and numerical modeling of two-component transient flow.

(*f*) Completed.

(*g*) Experimental and analytical work completed. Significant gas release is encountered with initial dissolved gas contents ranging from 2 to 200 percent by volume. Numerical analysis based on the method of characteristics satisfactorily predicts the transient phenomenon.

(*h*) **The Effect on Released Gases on Hydraulic Transients,** D. C. Wiggert, M. J. Sundquist, *Final Report for NSF Research Grant ENG 74-06653*, (Aug. 1977) NTIS Acc. No. PB 272899/AS.

Fixed-Grid Characteristics for Pipeline Transients, D. C. Wiggert, M. J. Sundquist, *J. Hyd. Div., ASCE* **103**, HY12 (Dec. 1977).

The Effect of Gaseous Cavitation on Fluid Transients, D. C. Wiggert, M. J. Sundquist, *Proc. Joint Symp. on Design and Operation of Fluid Machinery* **I**, Fort Collins, Colo., June 1978.

084-10991-340-82

FIELD STUDY AND ANALYSIS OF FLUID TRANSIENTS IN LARGE SCALE COOLING WATER SYSTEMS

(*b*) Georgia Institute of Technology and Electric Power Research Institute.

(*c*) David C. Wiggert, Associate Professor.

(*d*) Applied research including field investigations and theoretical analysis.

(*e*) The study includes acquisition of transient pressure and flow data from an existing full-scale cooling water system, in order to develop substantial and accurate design and analysis methodology. Specific tasks include monitoring of an extensive series of field tests conducted on a once-through cooling system; subsequent analysis of data to assess effects of gas release, column separation, air injection, etc., on the system pressure response; and develop a computer analysis model which incorporates recent state-of-the-art techniques.

(*g*) Field testing to begin Spring 1979.

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UNIVERSITY OF MICHIGAN, College of Engineering, Department of Aerospace Engineering, Ann Arbor, Mich. 48109. Professor R. M. Howe, Department Chairman.

085-10992-030-20

AN INVESTIGATION OF WALL PRESSURE FLUCTUATIONS ON CYLINDERS ALIGNED WITH THE FLOW

(*b*) Office of Naval Research.

(*c*) Professor William W. Willmarth.

(*d*) Experimental, basic research.

(*e*) Fluctuating pressure measurements on the cylinder surface.

(*g*) Development of pressure transducer to measure integrated surface pressure around circumference of cylinder.

(*h*) Sensor has been developed; not published at present.

085-10993-010-54

STRUCTURE OF TURBULENCE IN BOUNDARY LAYERS NEAR THE WALL

(*b*) National Science Foundation.
(*c*) Professor William W. Willmarth.
(*d*) Experimental, basic research, Doctoral thesis.
(*e*) Measurements of velocity fluctuations in air using small hot wires and in water using a high spatial resolution laser anemometer.
(*h*) **The Influence of the Flow Velocity on a Kovasznay Type Vorticity Probe,** E. G. Kastrinakis, H. Eckelmann, W. W. Willmarth. Accepted for publication in *Review Scientific Instruments* (about July 1979).
Nonsteady Vorticity Measurements: Survey and New Results, W. W. Willmarth, *Proc. Dynamic Flow Conf.*, Johns Hopkins Univ., Baltimore, Md., Sept. 18-21, 1978.

UNIVERSITY OF MICHIGAN, Department of Chemical Engineering, Ann Arbor, Mich. 48109. Professor J. S. Schultz.

086-09818-130-00

ACOUSTIC EMULSIFICATION (I)

(*d*) Theoretical and experimental.
(*e*) A technique has been developed to study the phenomenon of acoustic emulsification in which oil is dispersed as a fine suspension into water at 20 kHz. The acoustic emulsification process takes place in two stages. In the first stage, large oil droplets are formed from eruption of surface waves at the oil-water interface. In the second stage acoustic cavitation causes these large drops to break up into smaller drops.
The criterion of instability for the initial stage of emulsification has been derived from a linearized stability analysis of the oil-water interface under acoustic excitation. The characteristic droplet diameter produced by the instability is related to the induced capillary wavelength at the interface. The theoretical threshold amplitude of vibration necessary for the instability of the interfacial waves and the ultrasonic transducer amplitude are virtually the same. In addition the size of the large droplets present in the suspension systems at short irradiation times agree closely with the predicted droplet diameters.
It is known that intense cavitational shockwaves can be generated in the water medium under the influence of an ultrasonic field. In conjunction with the liquid-liquid emulsification phenomenon, a theoretical model for the deformation and break-up of an oil droplet was examined on the basis of the droplet being exposed to a cavitation shock. A relation from the model is expressed in terms of two dimensionless quantities, the Ohnesorge number and the critical Weber number ratio. These values, are then plotted and compared with the ones obtained from the studies on the liquid droplet exposed to shock impact from a gas stream, and the remarkable agreement leads one to the conclusion that large oil droplets originally formed from the oil-water interface as a result of the instability were disintegrated into smaller ones by the cavitation force until a critical size, characteristic of the oil-water system is reached.
(*h*) **On the Mechanism of Acoustic Emulsification–The Instability of the Oil Water Interface to Form the Initial Droplets,** H. S. Fogler, M. K. Li, *J. Fluid Mechanics* **88**, 449 (1978).
On the Mechanism of Acoustic Emulsification–Breakup of Large Primary Drops in a Water Medium, H. S. Fogler, M. K. Li, *J. Fluid Mechanics* **88**, 513 (1978).

UNIVERSITY OF MICHIGAN, College of Engineering, Department of Civil Engineering, Ann Arbor, Mich. 48109. Dr. E. F. Brater, Professor of Civil Engineering.

087-08850-410-60

A STUDY OF SHORE PROTECTION PROCEDURES

(*b*) Michigan Department of Natural Resources and NOAA Sea Grant Program.
(*c*) Dr. E. F. Brater.
(*d*) Laboratory and field investigation.
(*e*) The effectiveness and durability of various shore protection procedures are being investigated.
(*g*) The effectiveness of various shore protection procedures have been compared with unprotected conditions.
(*h*) **Laboratory Investigation of Shore Erosion Processes,** (with David Ponce-Compos), *Proc. 15th Intl. Conf. Coastal Eng., ASCE* **IV**, pp. 1493-1511, 1976.
Coastal Engineering and Erosion Protection, (with C. D. Ponce-Campos), *Tech. Rept. No. 59*, Mich. Sea Grant Progr., Jan. 1978.
Some Observations on Low Cost Shore Protection. Presented *Ann. Convention, ASCE*, Oct. 1978.

087-08853-210-54

TRANSIENT FLOW THROUGH OPEN AND CLOSED CONDUITS

(*c*) Professor E. B. Wylie.
(*e*) Study of unsteady fluid flow in pipes and liquid flow in open channels.
(*h*) **Control of Transients in Series Channel with Gates,** W. E. Bodley, E. B. Wylie, *J. Hyd. Div., ASCE* **104**, HY10, Oct. 1978.

087-09994-420-00

FORCES DUE TO WAVES AND CURRENTS ON RUBBLE COVERING PIPES BURIED IN OCEAN OR LAKE BOTTOMS

(*b*) University Research Funds.
(*c*) Professor E. F. Brater.
(*d*) For Doctoral thesis.
(*e*) The development of design criteria for cover layers exposed to waves and currents.
(*f*) Completed.
(*g*) Drag and inertial coefficients are related to dimensionless parameters to aid in the design of cover layers.
(*h*) Thesis: **The Stability of Protective Cover Layers for Embedded Underwater Structures,** Univ. of Mich., Tech. paper being prepared.

087-09995-390-54

NONLINEAR SHEAR WAVE PROPAGATION IN SOILS

(*b*) National Science Foundation.
(*c*) Professor E. B. Wylie.
(*d*) Theoretical, applied research.
(*e*) Study of one-dimensional shear wave transmission in layered soils.
(*h*) **Nonlinear Soil Dynamics by Method of Characteristics,** E. B. Wylie, R. Henke, *Proc. U.S. Natl. Conf. Earthquake Engrg.*, Stanford, Calif., Aug. 1979.

087-11424-050-54

TWO-DIMENSIONAL JETS IN STRATIFIED AND FLOWING AMBIENT FLUID

(*b*) National Science Foundation (Research Initiation Grant).
(*c*) Steven J. Wright.
(*d*) Experimental and theoretical basic research for Doctoral thesis.
(*e*) Examination of influence of linear density stratification or uniform crossflow velocity on the behavior of slot buoyant jet.
(*g*) Experiments to measure maximum rise in stratified fluid and associated dilution have been conducted.

087-11425-810-44

ESTIMATING RUNOFF FROM UNGAGED DRAINAGE BASINS

(*b*) Great Lakes Environmental Research Laboratory, NOAA.
(*c*) Dr. E. F. Brater.
(*d*) Basic research.
(*e*) Analysis of rainfall, temperature and runoff to develop a model for predicting monthly runoff into the Great Lakes.

087-11426-000-00

TWO- AND THREE-DIMENSIONAL FLUID TRANSIENTS

(*c*) Professor E. B. Wylie.
(*d*) Theoretical; applied research.
(*h*) **Multi-Dimensional Fluid Transients by Latticework,** E. B. Wylie, V. L. Streeter, *Symp. Fluid Transients and Acoustics in the Power Industry*, ASME, Dec. 1978.

087-11427-210-54

AIR RELEASE AND COLUMN SEPARATION IN PIPING SYSTEMS

(*b*) National Science Foundation, sub-contracted through Colorado State University. 0104(c)Professor E. B. Wylie.
(*d*) Experimental, theoretical.
(*e*) Evaluation of experimental data from both large and small diameter pipelines.
(*h*) **Column Separation in Horizontal Pipelines,** E. B. Wylie, V. L. Streeter, *Proc. Joint Symp. on Design and Operation of Fluid Machinery*, ASME, ASCE, IAHR, Colorado State Univ., Fort Collins, June 1978.

087-11428-820-54

RESPONSE OF NONLINEAR SATURATED SOILS TO SEISMIC DISTURBANCES

(*b*) National Science Foundation.
(*c*) Professor E. B. Wylie.
(*d*) Theoretical; applied research; Doctoral thesis.
(*e*) Study of liquefaction of soils during earthquakes.
(*h*) **Characteristic Method for Pressure Waves in Saturated Soils,** C. P. Liou, E. B. Wylie, *Proc. ASCE/EMD Specialty Conf.*, N.C. State Univ., Raleigh, N.C., May 1977.
Numerical Model for Liquefaction, C. P. Liou, V. L. Streeter, F. E. Richart, Jr., *J. Geotechnical Eng. Div., ASCE* 103, GT6, June 1977.

087-11429-690-70

NUMERICAL AND EXPERIMENTAL MODELING OF FUEL INJECTION SYSTEM

(*b*) Bendix Research Lab, Southfield, Mich.
(*c*) E. B. Wylie, S. J. Wright.
(*d*) Experimental and numerical applied research.
(*e*) Examination of transient response in fuel rail due to injector operation. Attempts to model unsteady friction effects for laminar and turbulent flow.
(*g*) Incomplete results at present.

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UNIVERSITY OF MICHIGAN, Cavitation and Multiphase Flow Laboratory, Department of Mechanical Engineering, Ann Arbor, Mich. 48109. Frederick G. Hammitt, Professor-in-Charge (reports on all projects available by writing to laboratory).

088-06147-230-54

BUBBLE NUCLEATION, GROWTH AND COLLAPSE PHENOMENA

(*b*) Office of Naval Research and Industry.
(*d*) Theoretical and experimental; basic research for various Ph.D. theses.
(*e*) Study of the details of inception, growth and collapse of vapor and gas bubbles in liquids. This has included the development of methods for measuring entrained gas microbubble spectra in water and correlating with cavitation nucleation pressure thresholds. Effects of fast neutron irradiation and strong magnetic fields have been included along with variation of temperature, pressure, settling-time, total gas content, etc. Present work emphasizes acoustic bubble collapse measurements and correlation with measured erosion rates. New automated multi-channel analyzer system for this purpose is now available.

088-08123-230-70

CAVITATION EROSION TESTING

(*b*) ONR and Industry.
(*e*) Measurement of chemical vs. mechanical effects in cavitation erosion as well as other details of erosion process.

088-08779-130-54

WET STEAM FLOWS

(*b*) National Science Foundation.
(*d*) Experimental and theoretical Ph.D. theses research.
(*e*) Experimental and theoretical investigation of low pressure wet steam flows (pertinent to low pressure end of large steam turbines) across blading profiles. Includes measurement of liquid film thicknesses on profiles, and downstream droplet size, velocity and population distributions, as well as theoretical studies of liquid film stability under high-velocity steam flows. Downstream liquid particle size and velocity distributions can be used as input for our droplet impact erosion work described in the previous project description. Effects of film orientation with respect to gravity and fluid properties as viscosity and surface tension to be next evaluated.

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UNIVERSITY OF MICHIGAN, Department of Naval Architecture and Marine Engineering, Ann Arbor, Mich. 48109. T. Francis Ogilvie, Chairman.

089-09869-520-54

SHIP MANEUVERING IN SHALLOW WATERS

(*b*) National Science Foundation.
(*c*) Professors R. Beck and T. Francis Ogilvie.
(*d*) Experimental, theoretical, basic research.
(*e*) An experimental and analytical study of ship operations in restricted waters is being made. Effects of vessel draft, size and ship interaction are under investigation.
(*g*) A method for predicting the forces and moments acting on a vessel due to the hydrodynamic interaction between vessels in passing situations is compared with experiments. Also experimental results on single ship maneuvering show speed effects in shallow water are more pronounced at the low speed limit.
(*h*) **Hydrodynamic Interactions Between Ships in Shallow Water,** T. W. Yung, *Report 201*, Dept. of Naval Architecture and Marine Engrg., June 1978.
Investigation Into Ship Maneuverability in Shallow Water by Free-Running Model Tests, M. Fujino, N. Daoud, *Report 203*, Dept. of Naval Architecture and Marine Engrg., Sept. 1978.

089-10994-520-20

SHIP CONTROL IN SHALLOW WATER

(*b*) Office of Naval Research.
(*c*) Professor M. G. Parsons.
(*d*) Theoretical, Doctoral thesis.
(*e*) The control of a surface ship along a prescribed straight-line path, subject to disturbances caused by another passing ship is considered.
(*f*) Completed.
(*g*) The effects of vessel speed and water depth on design are studied in detail.

(*h*) **Optimal Stochastic Path Control of Surface Ships in Shallow Water,** M. Parsons, H. T. Cuong, *Report 189*, Dept. of Naval Architecture and Marine Engrg., Aug. 1977.

089-10995-520-22

FORWARD SPEED EFFECTS ON THE ROLL MOTION OF SHIPS

(*b*) General Hydromechanics Research Program, Naval Sea Systems Command.
(*c*) A. Troesch, Assistant Research Scientist.
(*d*) Theoretical, basic research.
(*e*) The added mass and damping coefficients for sway, roll and yaw are formulated for a ship with forward speed.
(*f*) Completed.
(*g*) Numerical results show a significant change in the motion coupling coefficients.
(*h*) **Forward Speed Effects on the Sway, Roll, and Yaw Motion Coefficients,** A. Troesch, *Report 208*, Dept. of Naval Architecture and Marine Engrg., Nov. 1978.

UNIVERSITY OF MINNESOTA, Department of Aerospace Engineering and Mechanics, Minneapolis, Minn. 55455. Professor P. R. Sethna, Department Head.

091-07488-000-54

HYDRODYNAMIC STABILITY

(*b*) National Science Foundation.
(*c*) Professor Daniel D. Joseph.
(*d*) Theoretical; basic research; M.S., Ph.D. theses.
(*e*) Theoretical research on the stability of a broad class of fluid motions.
(*g*) The implications of energy analysis for the stability of classical motions (Couette and Poiseuille flows in annuli, pipes, channels, etc., and variations on the Benard problem) are emphasized. A global theory of stability is sought in which linear theory, energy theory and the theory of branching solutions of the Navier-Stokes equations play unique and complementary roles. Also developed are aspects of near-linear perturbation theories.
(*h*) **Slow Motion and Viscometric Motion: Stability and Bifurcation of the Rest State of a Simple Fluid,** D. D. Joseph, *Arch. Rational Mech. Anal.* **56,** 1974.
Stability of Bifurcating Time-Periodic and Steady Solutions of Arbitrary Amplitude, D. D Joseph, D. A. Nield, *Arch. Rational Mech. Anal.* **58,** p. 369, 1975.
Global Extensions of Hopf's Stability Theorems, D. D. Joseph, in *Proc. Mathematical Theory of Turbulence*, Springer Lecture Notes in Mathematics (Ed. R. Temam), 1975.
The Bifurcation of T-Periodic Solutions into nT-Periodic Solutions and Tori, D. D. Joseph, in *Proc. Intl. Workshop on Synergetics at Schloss Elmau*, Bavaria (Ed. H. Haken), Springer-Verlag, 1977.
Factorization Theorems, Stability and Repeated Bifurcation, D. D. Joseph, *Arch. Rational Mech. Anal.* **66,** pp. 99-118, 1977.
Bifurcation and Stability of nT-Periodic Solutions Branching from T-Periodic Solutions at Point of Resonance, D. D. Joseph, *Arch. Rational Mech. Anal.* **66,** pp. 135-172, 1977.

091-07489-020-54

THEORETICAL RESEARCH ON TURBULENCE

(*b*) National Science Foundation.
(*c*) Professor T. S. Lundgren.
(*d*) Theoretical basic research; M.S., Ph.D. theses.
(*e*) Appropriate closure hypotheses are sought for hydrodynamic turbulence.
(*f*) Completed.
(*g*) The work centered on the statistical mechanics of two dimensional vortices as a model for two-dimensional turbulence. A second area of interest was turbulent diffusion.
(*h*) **Statistical Mechanics of Two-Dimensional Vortices,** T. S. Lundgren, Y. B. Pointin, *J. Stat. Phys.* **17** (1977).
Equation of State of a Vortex Fluid, Y. B. Pointin, T. S. Lundgren, *Physical Review A* **13,** pp. 1274-1275 (1976).
Statistical Mechanics of Two-Dimensional Vortices in a Bounded Container, Y. B. Pointin, T. S. Lundgren, *Phys. Fluids* **19,** pp. 1459-1470 (1976).
NonGaussian Probability Distributions for a Vortex Fluid, T. S. Lundgren, Y. B. Pointin, *Phys. Fluids* **20,** pp. 356-363 (1977).
Turbulent Self-Diffusion, T. S. Lundgren, Y. B. Pointin, *Phys. Fluids* **19,** pp. 355-358 (1976).

091-08859-120-14

STUDIES IN THE VISCOMETRY OF SLOW MOTIONS OF RHEOLOGICALLY COMPLEX LIQUIDS

(*b*) U.S. Army Research Office.
(*c*) Professors D. D. Joseph, G. S. Beavers.
(*d*) Theoretical and experimental; basic and applied research; M.S., Ph.D. theses.
(*e*) Experimental and mathematical studies of the mechanics of flow of rheologically complex liquids are being carried out. The immediate aim is to enrich the science and technology of viscometry by developing sets of standard experiments, founded on sound mathematical analysis, which will lead to reliable viscometric data characterizing the slow motion of rheologically complex fluids. There is also interest in certain mathematical studies of the mechanical foundations of rheology and in the evolution of new methods of analysis.
(*g*) The following projects are active: (1) The rotating rod viscometer. (2) The Tilted Trough Viscometer. (3) Hele-Shaw flows. (4) Free surface viscometers driven by thermal convection. (5) Torsion flow viscometry.
(*h*) **The Rotating Rod Viscometer,** G. S. Beavers, D. D. Joseph, *J. of Fluid Mech.* **69,** p. 475, 1975.
Slow Motion and Viscometric Motion. Part V: The Free Surface on a Simple Fluid Flowing Down a Tilted Trough, L. Sturges, D. D. Joseph, *Arch. Rational Mech. Anal.* **59,** 4, p. 358, 1975.
The Free Surface on a Simple Fluid Between Cylinders Undergoing Torsional Oscillations, Part I, D. D. Joseph, G. S. Beavers, *Arch. Rational Mech. Anal.* **62,** p. 323, 1976.
The Free Surface on a Simple Fluid Between Oscillating Planes, Part III, L. Sturges, D. D. Joseph, *Arch. Rational Mech. Anal.* **64,** p. 245, 1977.
Perturbations of the Test State of a Simple Fluid: The Weissenberg Effect Induced by Torsional Oscillation of a Rod, D. D. Joseph, *Proc. VIIth Intl. Congr. Rheology*, 1977.
Free Surface Problems in Rheological Fluid Mechanics, G. S. Beavers, D. D. Joseph, *Rheologica Acta* **16,** p. 169, 1977.
Free Surface Problems Induced by the Motion of Viscoelastic Liquids, G. S. Beavers, D. D. Joseph, *Proc. ASME Symp. Viscoelastic Fluids*, Yale, 1977.
Novel Weissenberg Effects, D. D. Joseph, G. S. Beavers, *J. Fluid Mech.* **81,** p. 265, 1977.
Rotating Simple Fluids, D. D. Joseph, *Arch. Rational Mech. Anal.* **66,** pp. 311-344, 1977.

091-08860-000-70

ROTATING FLOWS

(*b*) Union Carbide Corporation, Nuclear Division.
(*c*) Professors A. S. Berman, T. S. Lundgren.
(*d*) Theoretical and experimental; basic research; M.S., Ph.D. theses.
(*e*) Study of spin up with and without density stratification and free surfaces.
(*h*) **Two-Fluid Spin-Up in a Centrifuge,** A. S. Berman, J. Bradford, T. S. Lundgren, *J. Fluid Mech.* **84,** pp. 411-431, 1978.

091-10573-070-54

FLUID FLOW THROUGH DEFORMABLE POROUS MEDIA

(*b*) National Science Foundation.
(*c*) Professor Gordon S. Beavers.
(*d*) Theoretical and experimental; basic and applied research; M.S., Ph.D. theses.
(*e*) The project aims to formulate and test mathematical models which will be capable of predicting the flow through deformable porous media, and which can be used for incompressible and compressible flows through many types of deformable media for geometries involving more than one principal flow direction.
(*g*) A model, based on the Forchheimer extension of the Darcy Law for flows through incompressible media, has been developed to describe the one-dimensional flow of an incompressible fluid through a deformable porous material. Mass flow rate predictions of the model agree well with experimental observations.
(*h*) **Compressible Gas Flow Through a Porous Material,** G. S. Beavers, E. M. Sparrow, *Intl. J. Heat and Mass Transfer* **14**, 11, pp. 1855-1857, 1971.
Experiments on the Resistance Law for NonDarcy Compressible Gas Flows in Porous Media, *J. Fluids Engrg., Trans ASME* **96,** Series I, 4, pp. 353-357, 1974.
Flow Through a Deformable Porous Material, G. S. Beavers, T. A. Wilson, B. A. Masha, *J. Appl. Mech.* **42,** *Trans. ASME* **97,** Series E, pp. 598-602, 1975.
Flow Through Permeable Beds Consisting of Layers of Different Size Spheres, G. S. Beavers, E. M. Sparrow, L. Goldstein, P. Bahrami, *AIChE J.* **22,** pp. 194-196, 1976.

UNIVERSITY OF MINNESOTA, St. Anthony Falls Hydraulic Laboratory (see ST. ANTHONY FALLS HYDRAULIC LABORATORY listing).

MISSISSIPPI STATE UNIVERSITY, Department of Aerospace Engineering, Mississippi State, Miss. 39762.

092-10137-000-26

DEVELOPMENT OF PARTIAL CHANNEL FLOW FOR ARBITRARY INPUT VELOCITY DISTRIBUTIONS USING BOUNDARY-FITTED COORDINATE SYSTEMS

(*b*) U.S. Army Research Office.
(*c*) Professor Leslie R. Hester, Principal Investigator; Professor Joe F. Thompson, Project Director.
(*d*) Theoretical, basic research, Ph.D. thesis.
(*e*) Work consists of applying a technique of automatic numerical generation of a curvilinear coordinate system (boundary-fitted coordinate systems) in the finite difference solution of the time dependent, two-dimensional Navier-Stokes equations for laminar as partial channel flow. The partial channel configurations of primary interst are those associated with fluid amplifiers or fluidic devices in which a nozzle or main flow issues into a region surrounded by both solid and fluid boundaries and is finally split into two channel flows which have solid boundaries. The configurations are of such small size and complex shapes that conventional experimental and analytical methods will not provide details of the flow field. Knowledge of the flow field is necessary in order to fully evaluate and optimize the configurations with respect to their steady state and dynamic performance. Since the end result of the boundary-fitted coordinate system is a rectangular grid with a square mesh upon which the numerical computation, both to generate the coordinate system and subsequently to solve the partial differential equations are performed, complex boundary shapes do not present a serious difficulty.
(*g*) A computer code has been developed that utilizes the boundary-fitted coordinate systems technique to provide field solutions in the primative variables for partial channel configurations with arbitrary shaped boundaries. The partial channel configuration can consist of a nozzle section, a main body section, two output sections and up to six main body ports. All sections can be of arbitrary shape. Velocity and pressure field solutions have been obtained for the case of symmetrical boundary conditions on the ports at a nozzle Reynolds Number of 500 based on nozzle width. The case of asymmetrical boundary conditions on the ports has been run, but because of problems associated with compatible boundary conditions on the ports, satisfactory resuls were not obtained.
(*h*) **Development of Partial Channel Flow for Arbitrary Input Velocity Distribution Using Boundary-Fitted Coordinate Systems,** *ASME Symp. NonSteady Fluid Dynamics, BK No. H00118*, pp. 53-61, Dec. 1978.
Recent Developments in the Use of Boundary-Fitted Coordinate Systems for Computational Mechanics, J. F. Thompson, Z. U. A. Warsi, C. W. Mastin, L. R. Hester, *8th U.S. Natl. Congress of Applied Mechanics*, Los Angeles, 1978.

MISSISSIPPI STATE UNIVERSITY, Department of Civil Engineering, Drawer CE, Mississippi State, Miss. 39762. Dr. R. M. Scholtes, Head.

093-11714-870-33

STATISTICAL ANALYSIS OF STREAMFLOWS AS APPLIED TO HYDROGRAPH CONTROLLED RELEASE OF LAGOON EFFLUENTS

(*b*) Mississippi Water Resources Research Institute, Mississippi State University.
(*c*) Dr. Victor L. Zitta.
(*d*) Theoretical applied research.
(*e*) The high initial and operating costs of alternative waste treatment processes dictate the retention of lagoons as a waste management alternative. Controlled release seems to be the most promising of the methods proposed to retain lagoons while maintaining the integrity of in-stream water quality standards. The controlled release method proposed in this study is to release during the rising portion of short term flow events. This implies a stochastic analysis of runoff events to determine the individual and joint probabilities of events to be expected during critical low flow conditions.
(*f*) Completion report due October 1, 1979.

093-11715-810-33

A SYSTEMATIC INVESTIGATION OF WATERSHED RUNOFF

(*b*) Office of Water Research and Technology.
(*c*) Dr. Vijay P. Singh, Associate Professor.
(*d*) Theoretical and applied.
(*e*) Kinematic wave models have been developed to study watershed surface runoff. A comparison of models has been made to develop objective criteria for their selection. To all watershed models precipitation forms input. An investigation of this input was carried out.
(*f*) Completed.
(*h*) **Studies on Rainfall-Runoff Modeling: 7. A Nonlinear Hydrologic Cascade,** S. Buapeng, V. P. Singh, *WRRI Report No. 087*, p. 68, New Mexico Water Resources Research Inst., New Mexico State Univ., Las Cruces, New Mexico, 1977.
Studies on Rainfall-Runoff Modeling: 8. Comparison of Models, V. P. Singh, *WRRI Report No. 91*, p. 82, New Mexico Water Resources Research Inst., New Mexico State Univ., Las Cruces, New Mexico, 1977.
Criterion to Choose Step Length for Some Numerical Methods Used in Hydrology, V. P. Singh, *J. Hydrology* **33,** pp. 287-299, 1977.
Sensitivity of Some Runoff Models to Errors in Rainfall-Excess, V. P. Singh, *J. Hydrology* **33,** pp. 301-388, 1977.

Effect of Rainfall-Excess Determination on Runoff Computation, V. P. Singh, S. Buapeng, *Water Resources Bulletin* **13,** 3, pp. 499-514, 1977.

Some Statistical Relationships Between Rainfall and Runoff, V. P. Singh, Y. K. Birsoy, *J. Hydrology* **34,** pp. 251-268, 1977.

Estimation of Parameters of a Uniformly Nonlinear Surface Runoff Model, V. P. Singh, *Nordic Hydrology* **8,** pp. 33-45, 1977.

Converging Overland Flow for Urban Runoff, V. P. Singh, K. L. Shelburne, *Proc. Intl. Symp. Urban Hydrology, Hydraulics and Sediment Control,* Univ. of Kentucky, Lexington, Ky., pp. 119-124, July 1977.

Estimation of Parameters of Converging Overland Flow Model, V. P. Singh, K. L. Shelburne, *Nordic Hydrology* **8,** pp. 193-210, 1977.

Comparison of Two Mathematical Models of Surface Runoff, V. P. Singh, *Intl. Assoc. of Hydrological Sciences Bulletin* **21,** 2, pp. 285-299, 1976.

Use of Topographic Information in Modeling Watershed Runoff Response, V. P. Singh, K. L. Shelburne, *Proc. Intl. Conf. on Water Resources Engrg.* **2,** Asian Inst. of Technology, Bangkok, Thailand, pp. 923-948, Jan. 1978.

Some Statistical Relationships Between Rainfall and Runoff–A Reply, V. P. Singh, Y. K. Birsoy, *J. Hydrology* **38,** pp. 383-386, 1978.

A Statistical Analysis of Rainfall-Runoff Relationship, V. P. Singh, Y. K. Birsoy, *Proc. Intl. Symp. on Risk and Reliability in Water Resources* **1,** Univ. of Waterloo, Waterloo, Ontario, Canada, pp. 345-363, Aug. 1978.

Role of Computers in Transfer of Water Resource Technology, V. P. Singh, *Water Knowledge Transfer* **1,** edited by Neil Grigg, pp. 540-556. Water Resources Publication, Fort Collins, Colo., 1978.

A Linear Dynamic Model for Prediction of Surface Runoff, V. P. Singh, *Modeling Hydrologic Processes,* edited by H. J. Morel-Seytoux, et al., Water Resources Publications, Fort Collins, Colo., 1979.

A Uniformly Nonlinear Model for Surface Runoff Prediction, V. P. Singh, *Modeling Hydrologic Process,* edited by H. J. Morel-Seytoux, et al., Water Resources Publication, Fort Collins, Colo., 1979.

A Nonlinear Hydrologic Cascade, V. P. Singh, S. Buapeng, *Proc. 3rd World Congress on Water Resources* **6,** Mexico City, Mexico, pp. 2633-2647, Apr. 1979.

A Uniformly Nonlinear Hydrologic Cascade, V. P. Singh, *J. Irrigation and Power,* 1979.

Use of Watershed Topography to Determine Converging Overland Flow Parameters, V. P. Singh, K. L. Shelburne, *Civil Engineering, The Institution of Engineers,* 1979.

A Systematic Evaluation of Urban Runoff Models, V. P. Singh, *Technical Report MSSU-EIRS-CE79-3,* 75 p., Engineering and Industrial Research Station, Mississippi State Univ., Mississippi State, Miss., 1979.

A Statistical Comparison of Urban Runoff Models, V. P. Singh, P. H. Blinco, presented *14th Amer. Water Resources Assoc. Ann. Mtg.,* Disney Land, Orlando, Fla., Nov. 1978.

A Coupled Runoff-Chloride Model for Urban Areas, A. J. H. Tay, V. P. Singh, *Proc. Intl. Symp. Urban Stormwater Management,* Univ. of Kentucky, Lexington, Ky., July 1978.

093-11716-810-54

A HYDRODYNAMIC STUDY OF SURFACE RUNOFF

(*b*) National Science Foundation.
(*c*) Dr. Vijay P. Singh, Associate Professor.
(*d*) Theoretical and applied.
(*e*) This project is aimed at developing a general, unified framework for the study of runoff process. Stochastic models of space-time varying rainfall are being developed from the vantage point of runoff modeling. Results of this study will augment current hydrologic knowledge of the runoff process.
(*h*) **A Mathematical Model of a Reservoir,** B. Sherman, V. P. Singh, *Proc. Intl. Conf. Mathematical Modeling, St. Louis, Mo., Aug.-Sept. 1977.*

Stochastic Simulation of Droughts, D. R. Dawdy, V. K. Gupta, V. P. Singh, *Proc. Bilateral U.S.-Argentina Workshop on Droughts,* Argentina, 1978.

Irrigation Hydraulics: Some Observations, V. P. Singh, *Proc. 3rd World Congress on Water Resources* **1,** Mexico City, Mexico, pp. 371-385, 1979.

Kinematic Modeling of Watershed Runoff: 1. Equilibrium Hydrograph, V. P. Singh, K. Mahmood, *Proc. 3rd World Congress on Water Resources* **4,** Mexico City, Mexico, pp. 2052-2073, Apr. 1979.

Kinematic Modeling of Watershed Runoff: 2. Partial Equilibrium Hydrograph, V. P. Singh, K. Mahmood, *Proc. 3rd World Congress on Water Resources* **4,** Mexico City, Mexico, pp. 2074-2086, Apr. 1979.

Kinematic Modeling of Watershed Runoff: 3. A Simultaneous Treatment of Infiltration, V. P. Singh, K. Mahmood, *Proc. 3rd Congress on Water Resources* **4,** Mexico City, Mexico, pp. 1087-2101, Apr. 1979.

Kinematic Modeling of Watershed Runoff: 4. Application to Natural Watersheds, V. P. Singh, K. Mahmood, *Proc. 3rd World Congress on Water Resources* **4,** Mexico City, Mexico, pp. 2101-2117, Apr. 1979.

Computer Modeling in Water Resources, V. P. Singh, K. Mahmood, *Proc. 1978 Summer Computer Simulation Conf.,* Newport Beach, Calif., June 1978.

Numerical Modeling of Sediment Transport in Hydraulic Structures, K. Mahmood, V. P. Singh, *Proc. 1978 Summer Computer Simulation Conf.,* Newport Beach, Calif., June 1978.

Mathematical Modeling of Watershed Runoff, V. P. Singh, *Proc. Intl. Conf. Water Resources Engrg.* **2,** Asian Institute of Technology, Bangkok, Thailand, pp. 703-726, Jan. 1978.

A Kinematic Model for Surface Irrigation, B. Sherman, V. P. Singh, *Water Resources Research* **14,** 2, pp. 357-363, 1978.

093-11717-810-54

FREE BOUNDARY PROBLEMS IN WATER RESOURCE ENGINEERING

(*b*) National Science Foundation.
(*c*) Dr. Vijay P. Singh, Associate Professor.
(*d*) Theoretical and applied.
(*e*) This project deals with a mathematical treatment of free boundary problems in surface runoff, soil erosion by water, and surface irrigation, as well as application of the techniques to natural environments.
(*g*) Explicit analytical solutions have been obtained for some of the free boundary problems arising in surface runoff, surface irrigation, and watershed sediment yield. Progress report due Mar. 1981.

UNIVERSITY OF MISSOURI-COLUMBIA, Civil Engineering Department, Columbia, Mo. 65211. John T. O'Connor, Department Chairman.

094-10999-260-52

HYDRAULIC CAPSULE PIPELINING (HCP)

(*b*) U.S. Department of Energy, EM-78-S-02-4935.
(*c*) Dr. Henry Liu, Professor.
(*d*) Theoretical and experimental, applied research, Master's and Doctoral theses.
(*e*) Assess the feasibility of HCP (hydraulic capsule pipeline) for freight transport over long distances, and to design a small system for demonstration. Main technical problems studied are capsule pumping and injection.

(*g*) The study indicates that HCP is technically and economically feasible for a number of applications. It also uses less energy than other modes of freight transport, and is pollution free. The most immediate application seems to be for coal transport over distances in the range 50-300 miles. The most promising method of pumping seems to be by using linear motors, although jet pump also may play an important role. Best ways to inject and handle capsules also have been tentatively identified.

(*h*) **The Fluid Mechanics of Capsule Pipelining,** H. Liu, *Spec. Conf. of the Engr. Mech. Div., ASCE*, 7 pages, May 1977.
Electromagnetic Capsule Pumps, H. Liu, J. E. Rathke, *Intl. Symp. on Freight Pipeline*, Washington, D.C., Dec. 1976.
Conserving Energy and Protecting Environment by Using Freight Pipeline–A Technology Assessment, *4th Ann. UMR-DNR Conf. on Energy*, Rolla, Mo., 9 pages, Oct. 1977.
Transporting Coal in Containers Through Pipeline–A Feasibility Study, H. Liu, *5th Ann. UMR-DNR Conf. on Energy*, Rolla, Mo., 9 pages, Oct. 11, 1978.

094-11000-300-33

PREDICTING LONGITUDINAL DISPERSION IN NATURAL STREAMS

(*b*) Office of Water Research and Technology, U.S. Department of the Interior, A-103 MO.
(*c*) Dr. Henry Liu, Professor.
(*d*) Theoretical, basic research, Master's thesis.
(*e*) Conventional ways to predict longitudinal (one-dimensional) dispersion of pollutants in natural streams are often grossly inaccurate. The purpose of the study is to develop a new method to improve the accuracy of prediction.
(*f*) Completed.
(*g*) The ordinary Fickian model for dispersion is modified by using a time-dependent dispersion coefficient and a time-scale much greater than Fischer time-scale. With such a model, it was found that longitudinal dispersion in natural streams can be predicted with much better accuracy than hitherto considered possible. The result is useful for predicting pollution of river caused by accidental spills.
(*h*) **Predicting Dispersion Coefficient of Streams,** H. Liu, *J. Env. Engr. Div., ASCE, Proc. Paper 12724*, pp. 59-69, Feb. 1977.
Predicting Longitudinal Dispersion of Pollutants in Rivers, H. Liu, J. E. Dieter, *25th Ann. Hyd. Spec. Conf., ASCE*, Aug. 1977.
Pollution Forecast in Streams, H. D. Cheng, *M.S. Thesis*, Univ. of Missouri-Columbia, 92 pages, July 1978.

UNIVERSITY OF MISSOURI-COLUMBIA, Department of Geology, Columbia, Mo. 65211. James H. Stitt, Chairman.

095-10063-300-00

CHANNEL INCISION CHRONOLOGY AND PALEOHYDRAULICS OF THE DEARBORN RIVER, MONTANA

(*b*) Research Council of the Graduate School, University of Missouri-Columbia.
(*c*) Asst. Professor Michael G. Foley.
(*d*) Field investigation, basic and applied research.
(*e*) The present lower course of the Dearborn River is deeply incised into bedrock, but was apparently established by diversion by a late Pinedale glacial advance. A relict braided outwash channel formerly occupied by the Dearborn River, and now occupied by Flat Creek, an underfit stream, was a sluiceway at the time of diversion. A diversion chronology established by detailed mapping, and paleoflow characteristics determined by hydraulic analysis of the abandoned channel allow a quantitative rate of bedrock channel incision and adjustment to be determined. This chronology is being used to calibrate a model for bedrock incision by streams.
(*h*) **Toward a Deterministic Model of Bedrock Incision by Streams,** M. G. Foley, (*Abs.*): *Geol. Soc. Am. Abstracts with Programs*, in press.

095-10064-300-00

INCISION MECHANISM AND HYDRAULICS OF THE SALINE RIVER, ARKANSAS

(*c*) Asst. Professor Michael G. Foley.
(*d*) Field investigation, basic and applied research, Master's thesis.
(*e*) The Saline River displays a bead-on-a-string pattern related to its riffle-and-pool morphology. Reconnaissance indicates that some of the riffle-and-pool morphology is incised in bedrock, and therefore does not indicate direct control by alluvial sediment transport, as does riffle-and-pool morphology of an alluvial stream channel. Field mapping and hydraulic studies will be used to investigate the relation between bedrock channel geometry and alluvial transport processes.
(*f*) Suspended.

095-10065-820-33

HYDROGEOLOGY AND GEOPHYSICAL DELINEATION OF BURIED GLACIAL RIVER VALLEY AQUIFERS IN NORTHWESTERN MISSOURI

(*b*) Office of Water Research and Technology (U.S.D.I.).
(*c*) Asst. Professor John M. Sharp, Jr.
(*d*) Field investigation, applied research, Master's thesis.
(*e*) Examine the hydrogeology of buried glacial river valley (or preglacial valley) aquifers; delineate these aquifers; determine their lateral and vertical extent; and to compare geoelectric, gravity, and seismic refraction geophysical methods for groundwater exploration in this particular hydrogeologic setting. We plan to quantitatively estimate: 1) aquifer hydraulic conductivity and storativity, 2) areas of groundwater recharge and discharge, 3) the hydrologic budget, and 4) groundwater salinities. We shall also determine the direction and rates of groundwater flow and the existence of any hydrostratigraphic units. Long-range goals are to determine the aquifer's potential water yield and to provide information for regional planning. A clearly subsidiary objective is to provide data to assist in the reconstruction of Missouri's Pleistocene (Ice-age) history.
(*g*) Gravity grid surveing has proven to be an effective reconnaissance tool when coupled with well log data. The need for better elevation control was documented and supplied by barometric altimetry and secondary bench marks. Seismic refraction has demonstrated effective in determining depth to bedrock, but electrical resistivity has been ineffective because of saline water encroachment from bedrock.
(*h*) **Applicability of Gravity and Seismic Methods for Delineating Northwest Missouri's Buried River Valley Aquifers,** O. Malvik, R. F. Burmester, J. M. Sharp, Jr., *Missouri Acad. Sci. Trans.*, 1979.
Hydrogeology and Delineation of Buried River Valley Aquifers in Northwestern Missouri, J. M. Sharp, Jr., *Missouri Water Resources Research Center* (*NTIS PB-278-035*), 65 p., 1977.
Geophysical Exploration for Buried River Valley Aquifers in the Dissected Till Plains, J. M. Sharp, Jr., R. F. Burmester, O. Malvik, *Geol. Soc. Amer., Abs. with Programs* (*North-Central Sec.*) **10**, 6, p. 284, 1978.
Geophysical Delineation of Buried River Valley Aquifers in Northwestern Missouri, O. Malvik, R. F. Burmester, J. M. Sharp, Jr., *Am. Geophys. Union, Midwest Mtg.*, p. H-1, 1977.

095-10066-300-33

HYDROGEOLOGIC CHARACTERISTICS OF THE MISSOURI RIVER VALLEY FLOOD PLAIN ALLUVIAL AQUIFER

(*c*) Asst. Professor John M. Sharp, Jr.
(*d*) Field investigation, basic and applied research, Master's thesis.

(*e*) Examine quantitatively the hydrologic and geologic characteristics of the Missouri River flood plain alluvial aquifer. This includes quantification of the aquifer's anisotropy and inhomogeneity, its storativity and hydraulic conductivity, and its hydrostratigraphy. A subsidiary objective is to develop a generalized digital model for groundwater movement in the flood plain. The long-range goal is to employ the above information and model to the selection of utilization criteria for waste disposal and water supply in the Missouri River flood plain.

(*g*) A series of finite difference computer models have been developed to simulate observed fluctuations in hydrogeologic conditions. Our conclusions are as follows: 1) The flood plain shows greater hydrogeologic variability than was previously assumed; 2) influence of local streams and springs can lead long-term perturbations in "normal" flood plain hydrogeology; 3) many of the assumptions commonly made in bank storage models are erroneous; 4) flood plain groundwater systems may be separated into local and regional systems; 5) hydraulic jetting of wells has proven to be an economical method for installation of piezometers; 6) the flood plain is a major untapped groundwater resource which will be increasingly developed for supplemental irrigation, industrial, and domestic use; and 7) hydrogeologic information is vital to the proper land use selection in flood plains. Furthermore, an initial quantification of aquifer anisotropy has been made. Sites most suitable for water supply and waste disposal have been evaluated and criteria established.

(*h*) **Hydraulic Properties of the Missouri River Alluvial Aquifer,** T. L. Foreman, J. M. Sharp, Jr., *Geol. Soc. Amer., Abs. with Programs (North-Central Sec.)*, 1979.

Alluvial Hydrogeology of the Lower Missouri River Valley, N. G. Grannemann, J. M. Sharp, Jr., *J. Hydrology*, in press.

Limitations of Bank-Storage Model Assumptions, J. M. Sharp, Jr., *J. Hydrology* **35,** 1/2, p. 31-47, 1977.

Major River Valley Flood Plains Hydrogeology, J. M. Sharp, Jr., N. G. Grannemann, *Geol. Soc. Amer., Abs. with Programs (North-Central Soc.)* **9,** 5, p. 650-651, 1977.

Hydrogeologic Characteristics of the Missouri River Valley Flood Plain, J. M. Sharp, Jr., *Missouri Water Resources Research Center (NTIS PB-261-355)*, 60 p., 1976.

5-11001-810-60

SSOURI'S INSTREAM FLOW

) Office of Administration, State of Missouri.

) Asst. Professor John M. Sharp, Jr.

) Applied research, Master's thesis.

) Investigation on a watershed by watershed scale of low flows versus current and projected water demands. The study seeks to identify specific watersheds in Missouri which are in danger of overdraft. Data is presently collected by a wide range of local state and federal agencies. We intend to collect this data; focus it on instream flow requirements; and delineate areas of future study.

-11002-650-84

DELING THE EFFECTS OF COMPACTION DISQUILIBRIUM AND AQUATHERMAL PRESSURING IN CCUMULATING SEDIMENTS

Asst. Professor John M. Sharp, Jr.

American Chemical Society (Petroleum Research Fund).

Theoretical investigation, basic and applied research, at least one thesis (either Master's or Doctoral).

Project involves computer modeling the effects of sediment loading and aquathermal pressuring in determining pressures and temperatures in accumulating sediments. The cause of excess pressures in thick sedimentary sequences has long been a cause of controversy. In this research we focus on the two most promising candidates and are attempting to evaluate their simultaneous effects. The results of this project could be important in studies of sediment diagenesis, geothermal energy, and the formation of petroleum and economic mineral deposits.

(*g*) Preliminary results tie aquathermal pressuring closely to sediment compressibility. A simple computer subroutine has been developed to calculate the isobaric expansivity and isothermal compressibility of water in the range of 20-250 °C and 1-6000 kb.

UNIVERSITY OF MISSOURI—COLUMBIA, College of Engineering, Department of Mechanical and Aerospace Engineering, Columbia, Mo. 65201. Paul W. Braisted, Department Chairman.

096-09831-050-54

HETEROGENEOUS JET MIXING STUDY USING LASER ANEMOMETER

(*b*) National Science Foundation ENG-74-10074.

(*c*) Dr. John B. Miles, Professor.

(*d*) Experimental; basic research; Master's and Doctoral theses.

(*e*) Investigate both the overall and the detailed nature of the heterogeneous turbulent mixing region formed by the interaction of two parallel streams (one air, the other Freon) initially separated by a thin dividing plate. Instantaneous local velocities are measured (2 components) by a laser anemometer system. Local concentration is measured by an aspirating probe in conjunction with a hot wire anemometer. All data is recorded on an FM tape recorder for subsequent evaluation in terms of power spectrums, time averages, and various correlations.

(*f*) Project has been completed. Dissertation of James L. Brown is being prepared for submission to appropriate journals.

(*g*) An experimental investigation of the two stream turbulent mixing layer has been conducted. Studied were three velocity ratio homogeneous cases, $\phi_0 = 0$, 0.3, and 0.6, for air mixing with air. Also studied were two velocity ratio heterogeneous cases, $\phi_0 = 0.3$ and 0.6 with air as the fast stream and freon-12 as the slow stream. The fast stream in all cases was air at a nominal velocity of 14 mps. A Reynolds number, u_1X/ν, of $1.8 \cdot 10^5$ to $3.2 \cdot 10^5$ was typical of the cases considered. Velocity measurements were accomplished for all cases considered. Several velocity instruments were employed in this study. These instruments included a pitot tube, a hot wire anemometer, and a 2-D, 2-Color laser Doppler anemometer. Molar concentration of freon-12 was measured using a hot-wire based aspirating probe. Experimental mean velocity, $\bar{u}$, and mean concentration, $\bar{c}$, profiles in the similarity region are presented for mixing layer cases mentioned above. Turbulence intensities (u'_{rms}, v'_{rms} and c'_{rms}), Reynold stresses ($\overline{u'v'}$, $\overline{c'u'}$ and $\overline{c'v'}$), associated spectrums, auto- and cross-correlations are obtained. A spreading rate parameter, σ, is presented for each case. Velocity spectrums are also obtained for the near region initial instability. Flow visualization photographs were obtained through the injection of smoke into one or the other of the two streams. These flow visualization studies lend added support of and insight into the coherent structures governing the mixing layer. A flow pattern for these structures is evolved which explains considerable experimental observations. Certain conclusions as to the behavior of the turbulent mixing layer can be made based upon the results of the current study. These conclusions include: (1) The analytical solutions of Baker & Weinstein based upon Prandtl's second mixing length hypothesis accurately predict the velocity profiles for both the homogeneous and heterogeneous mixing layers. (2) The growth rate of a turbulent mixing layer with laminar boundary layers at the splitter plate and *undisturbed* initial conditions is best described by Sabin's relationship: $\sigma / \sigma_0 = (1 - \phi_0)/(1 + \phi_0)$ with $\sigma_0 = 11.5$ (a best fit value). The σ vs ϕ_0 relation of Sabin is felt to be valid for both the homogeneous and heterogeneous turbulent mixing layers as long as *laminar* boundary layers exist at the splitter plate and the initial conditions are undisturbed. However, if the turbulent mixing layer is disturbed, par-

ticularly the near region, then a faster growth rate (lower σ) will be experienced. (3) A value of 1.0 for the turbulent Schmidt number was found to best fit the experimental heterogeneous velocity and concentration profiles to their analytical counterparts. (4) The effect of a density difference in the two streams of a subsonic turbulent mixing layer on the σ vs ϕ_o relation is found to be statistically insignificant. (5) The laminar instability as described by Michalke predominates in the near region of the mixing layer of the present study. (6) The importance of the initial conditions near the splitter plate on the growth rate and characterisitcs of the resultant turbulent mixing layer are emphasized in this study. (7) Evidence of the large scale coherent structures as dominating the turbulent mixing layer is displayed in the velocity and concentration spectrums and correlations obtained in the present study. (8) Further evidence of the mixing layer structures is presented in the form of flow visualization photographs.

(*h*) **Heterogeneous Turbulent Mixing Layer Investigations Utilizing a 2-D 2-Color Laser Doppler Anemometer and a Concentration Probe,** J. L. Brown, *Ph.D. Dissertation*, Univ. of Missouri-Columbia.

096-11003-140-50

NUCLEATE BOILING AT ZERO-GRAVITY

(*b*) NASA-Ames Research Center.
(*c*) Dr. John B. Miles, Professor.
(*d*) Experimental; basic research; Doctoral thesis.
(*e*) Boiling from preselected nucleation sites on heated copper surfaces is being studied in a near zero-gravity situation. The boiling surfaces are the smoothed and polished ends of one-inch diameter cylinders which have different arrays of small holes drilled into them to provide preferred sites for nucleate boiling. The low gravity environment is provided by flying the experiment in a Learjet aircraft which performs a parabolic trajectory during actual data acquisition. Some boiling surfaces are maintained at constant heat flux. Principal instrumentation includes time-varying temperatures and heat fluxes plus high speed motion pictures of bubble growth and departure.
(*f*) Phase I has been completed. Some experimental problems encountered in Phase I are being modified in preparation for a second round of experiments.
(*g*) A NASA Learjet was used to produce a low gravity environment for a series of nucleate pool boiling experiments. Surface temperature and heat flux measurements, and high-speed microphotography of bubble phenomena, were made on 9 prepared boiling surfaces. The surfaces were polished copper disks, 25 mm in diameter, with variable artificial nucleation site densities from 0.2 to 32 sites/cm^2. Both lg and low g data were obtained for comparison. In every case, the boiling heat transfer coefficient was observed to increase to a new, apparently steady value for the entire 15-20 second duration of the low-gravity period. The mean increase in the heat transfer coefficient was 34 percent. Rapid movement of the surfaces of the large vapor masses which were observed is indicative of considerable turbulent liquid motion apparently induced by the bubble growth and coalescence. In no case was a decreased heat transfer coefficient observed, which would be indicative of film boiling.
(*h*) **Nucleate Pool Boiling of Water on Arrays of Artificial Sites in Normal and Reduced Gravity Environments,** B. W. Webbon, *Ph.D. Dissertation*, Univ. of Missouri-Columbia.

UNIVERSITY OF MISSOURI—ROLLA, School of Engineering, Department of Chemical Engineering, Rolla, Mo. 65401. Professor Gary K. Patterson.

097-07502-120-00

MEASUREMENT OF COMPLEX MODULUS IN POLYMERS

(*c*) Dr. Gary K. Patterson.
(*d*) Experimental; basic; Masters thesis.
(*e*) Development and testing of an instrument for measurement of complex shear modulus in polymer solutions and soft solids. The instrument is also applicable to greases and other complex suspensions.
(*g*) Two modes of operation have proven feasible: (1) for dilute to concentrated polymer solutions and greases, vibration of a thin plate in effectively infinite solution; and (2) for soft solids vibration of a very rigid plate clamped between two relatively thin samples of polymer. Tests of instrument effectiveness are continuing.

097-07503-020-00

EFFECTS OF MIXING ON CHEMICAL REACTIONS

(*b*) National Science Foundation.
(*c*) Drs. G. K. Patterson and S. B. Hanna.
(*d*) Theoretical and experimental; basic; Masters and Doctoral theses.
(*e*) Segregation and concentration distributions of reactants and products are measured in mixed reactors to determine how well they can be modeled by various methods. Extension to complex reactions is being done.
(*g*) Measurements of second-order very fast reaction in coaxial jet flows and model results compare closely. Some measurements done in mixing tank using fluorescent product method. Modeling using analytical closure for complex reactions has produced promising results.
(*h*) **Turbulence Level Significance of the Coalescence-Dispersion Parameter,** *Chem. Eng. Sci.* **32,** 1349 (1977).
Effect of Imperfect Mixing on the Performance and Control of Batch and Semi-Batch Reactors, (with R. C. Waggoner), *ISA Trans.* **14,** 331 (1975).
Applications of Random Coalescence-Dispersion, *Proc. 4th Intl. Symp. on Chem. Reactor Eng.*, Heidelberg, Apr. 1976.
Measurement and Numerical Modeling of Turbulent Scalar Mixing and Reaction in Co-Axial Jets, (with W. C. Lee and S. J. Calvin), *Symp. on Turb. Shear Flow*, Penn. State Univ., Apr. 1977.
Modeling Complex Chemical Reactions in Flows with Turbulent Diffusive Mixing, *70th Ann. AIChE Mtg.*, Nov. 1977.
Methods for Computing Yield for Turbulently Mixed Complex Reactions, *AIChE Ann. Mtg.*, Miami Beach, Dec. 1978.
Closure Approximations for Complex Multiple Reactions, *2nd Symp. on Turb. Shear Flow*, London, July 1979.

097-11007-250-50

FLOW OF SMALL PARTICLES IN AIR BOUNDARY LAYERS

(*b*) National Aeronautics and Space Administration.
(*c*) Drs. G. K. Patterson, R. B. Oetting and R. Anderson.
(*d*) Experimental; basic; Masters thesis.
(*e*) Visual studies by holography and high speed movies of particle motions in a boundary layer developing on a long flat plate in a large wind tunnel are being done to show why drag reduction sometimes occurs. Various types of particles under differing charge conditions are being used.
(*g*) System for studies just completed.

097-11008-250-00

FIBER SUSPENSION FLOWS

(*c*) Dr. G. K. Patterson.
(*d*) Experimental; basic.
(*e*) Studies of the flow characteristics of fiber suspensions, including paper pulps, to determine effects of flocculation on dray characteristics and fiber dispersion.
(*g*) Apparent drag reduction in pipe flow, which appears at a flow rate where turbulence should commence and disappears at a higher flow rate, is probably cuased by nonuniform distribution of fiber concentration. Visual studies using high speed movies are planned.

UNIVERSITY OF MISSOURI—ROLLA, Department of Civil Engineering, Rolla, Mo. 65401. Joseph H. Senne, Department Chairman.

098-06287-810-00

MODIFIED STATION-YEAR METHOD FOR FLOOD FREQUENCIES

(*c*) Dr. T. E. Harbaugh.
(*d*) Design.
(*e*) Determination of flood peaks for small drainage areas in Missouri based on physiographic data.
(*f*) Completed.

098-07504-200-00

EFFECTS OF RAINDROP IMPACT ON OVERLAND FLOW

(*c*) Dr. G. T. Stevens, Jr.
(*d*) Experimental.
(*e*) Work is being performed in the laboratory to determine the effect of raindrop impact as a contributing factor in the resistance to flow for short overland flow conditions.
(*f*) Completed.

098-07505-350-88

TIME SEQUENCED DAM FAILURES

(*b*) National Defense Education Act.
(*c*) Dr. T. E. Harbaugh.
(*d*) Experimental.
(*e*) Determination of the influence of a controlled breaking of a dam upon the ensuing downstream flood wave.
(*h*) Ph.D. Dissertation completed.

098-07506-220-33

EVALUATION OF A SINGLE LAYER OF GRADED GRAVEL AS A PROTECTIVE FILTER ON EMBANKMENT SLOPES

(*b*) Office of Water Resources Research.
(*c*) C. D. Muir, Assoc. Professor.
(*d*) Experimental.
(*e*) Determine the effect of thickness and gradation on the ability of a single graded filter layer to prevent the migration of finer particles through the layer.
(*h*) Master's Thesis completed.

098-07507-200-00

A SENSITIVITY ANALYSIS OF THE SPATIALLY VARIED UNSTEADY FLOW EQUATIONS

(*c*) Dr. T. E. Harbaugh.
(*d*) Theoretical.
(*e*) Computer solutions of the spatially varied flow equations are being performed for various boundary, finite difference, mesh sizes, and inputs to determine the sensitivity of the equations to a variety of parameters.
(*h*) Ph.D. Dissertation (G. T. Stevens, Jr.) completed.

098-08862-220-13

VELOCITY DISTRIBUTION VERSUS SEDIMENT IN THE MISSOURI RIVER

(*b*) Dept. of the Army, Kansas City Dist., Corps of Engineers.
(*c*) Dr. G. T. Stevens, Jr.
(*d*) Applied research.
(*e*) An attempt was made to fit experimentally developed sediment transport equations to the Missouri River.
(*f*) Completed.
(*h*) Completed Master's Thesis. A. Mauzy.

098-08863-300-13

THE MISSOURI RIVER COMPUTERIZED DATA BANK

(*b*) Dept. of the Army, Kansas City Dist., Corps of Engineers.
(*c*) Dr. G. T. Stevens, Jr.
(*d*) Applied research.
(*e*) Collection and storage of all available velocity and sediment data that is needed in the development of a typical Missouri River velocity and sediment concentration profile. These profiles then can be utilized in a sediment transport relationship for the Missouri River.
(*f*) Completed.

098-08864-810-00

UNIT HYDROGRAPH FOR OZARK SECTION OF SOUTHWEST MISSOURI

(*c*) Dr. G. T. Stevens, Jr.
(*d*) Design.
(*e*) Development of a synthetic unit hydrograph for the Ozark section of Missouri and Arkansas using readily available physiographic data.
(*h*) Master's Thesis completed, Melvin Schaefer.

098-08865-310-00

A MULTIPLE-PLAN EVALUATION MODEL FOR SMALL UNGAGED WATERSHEDS

(*c*) Dr. G. T. Stevens, Jr.
(*d*) Design.
(*e*) A computer model for simulation of the effect of alternative measures for flood damage reduction. The goal is to optimize the value of an objective function which will maximize the amount of net benefits returned by the project.
(*h*) Completed Master's Thesis, J. R. Dexter.

098-08866-810-00

A COMPARISON OF THREE URBAN HYDROLOGY MODELS

(*c*) Dr. G. T. Stevens, Jr.
(*d*) Design, Master's thesis.
(*e*) A comparison of three models used for the calculation of urban stormwater runoff is presented. Simulation results are based on the capability of these models to reproduce observed peak discharges, time to peak and the direct runoff volume.
(*h*) Completed Master's Thesis, R. F. Astrack.

098-08867-810-00

A STATISTICAL HYDROLOGIC SIMULATION MODEL

(*c*) Dr. G. T. Stevens, Jr.
(*d*) Applied research, design.
(*e*) A simulation model for small watersheds using probabilistic models derived from short term rainfall–runoff records are developed. The model is used to generate a synthetic flood series which is compared to the observed flood series.
(*h*) Completed Master's Thesis, R. L. Wycoff.

098-08868-350-00

RESERVOIR DESIGN: SIMULATION TECHNIQUES

(*c*) Dr. G. T. Stevens.
(*d*) Design, applied research.
(*e*) A computerized simulation model using hydrologic routing techniques is developed to aid in the analysis of small dams to reduce the possibility of inadequate spillway design. Simulation equation derived from the continuity equation to describe reservoir storage and outflow. Newton's iteration technique is utilized to solve the simulation equations. The resulting model determines an optimum size auxiliary spillway having a minimum crest length for a range of spillway elevations.
(*h*) Completed Master's Thesis, L. W. Mays.

098-08869-880-13

MISSOURI RIVER ENVIRONMENTAL INVENTORY

(*b*) Dept. of the Army, Kansas City Dist., Corps of Engineers.
(*c*) Dr. P. R. Munger.
(*d*) Field investigation.
(*e*) Study was conducted to obtain baseline information which could be used in preparation of an operation and main-

tenance environmental impact statement by the Corps. The investigation consisted of a literature review and selected field studies of the aquatic ecosystems and natural resources bordering the river.
(*f*) Completed.

098-08870-880-13

A BASE LINE STUDY OF THE MISSOURI RIVER

(*b*) Dept. of the Army, Kansas City Dist., Corps of Engineers.
(*c*) Dr. P. R. Munger.
(*d*) Field investigation.
(*e*) To increase the understanding of the interrelationships which exist between the activities conducted by the Corps of Engineers in, on, and in the vicinity of, the Missouri River and the environment of the region traversed.
(*f*) Completed.

098-08871-870-00

ENVIRONMENTAL INVENTORY AND ASSESSMENT OF AREAS I, II, III, AND IV, ARKANSAS RIVER CHLORINE CONTROL PROJECT, OKLAHOMA AND KANSAS

(*c*) Dr. Ju-Chang Huang.
(*d*) Field investigation.
(*e*) Collect background information of environmental resources, including geological feature, hydraulic and hydrological characteristics, water quality, socio-economical conditions, aquatic and terrestrial biology, etc., of the four study areas associated with the Arkansas River Chloride Control Project. Assessments of potential environment impacts which will be incurred as a result of the chloride control project implementation will be made in this investigation.
(*f*) Completed.

098-10011-300-13

LOWER MISSISSIPPI VALLEY DISTRICT POTAMOLOGY STUDY (T-I)

(*b*) Department of the Army, St. Louis District, Corps of Engineers.
(*c*) Paul R. Munger.
(*d*) Field investigation and applied research.
(*e*) To compile available data on revetments and dikes, geology and hydrology, morphology, and levees, over a large reach of the Mississippi River. To indicate, where possible, relationships between the changes that have taken place in the river over time and the above factors. To inspect field information and to indicate insufficiencies and data gaps that presently exist.
(*f*) Completed.

098-10012-300-13

LOWER MISSISSIPPI VALLEY DISTRICT POTAMOLOGY STUDY (S-7)

(*b*) Department of the Army, St. Louis District, Corps of Engineers.
(*c*) Jerome A. Westphal.
(*d*) Field investigation and applied research.
(*e*) To document changes which occurred in the Middle Mississippi River along with the associated human activity which influenced changes. River elements were examined for changes in top-bank width, cross sectional area at selected locations, invert profile, and river length along the thalweg. Human activities were examined in conjunction with changes in river channel elements. These included construction of dikes, levees, revetments, and bank clearing. All comparisons and anaysis reflected conditions from the earliest recorded description through 1974.
(*f*) Completed.

098-10013-700-13

ST. LOUIS DISTRICT POTAMOLOGY STUDY (S-3)

(*b*) Department of the Army, St. Louis District, Corps of Engineers.
(*c*) Glendon T. Stevens, Jr.
(*d*) Field investigation and applied research.
(*e*) Comparison of velocity measuring equipment and discharge calculating techniques; to determine if there is a difference between present day and those previously used techniques.
(*f*) Completed.

098-11009-300-13

ST. LOUIS DISTRICT POTAMOLOGY STUDY (S-9)

(*b*) Department of the Army, St. Louis District, Corps of Engineers.
(*c*) Jerome A. Westphal.
(*d*) Applied research.
(*e*) Formulation of course of action which will ultimately lead to quantitative understanding of impact of land use practices and river control structures on flows of the Middle Mississippi River.
(*f*) Completed.

098-11010-300-13

ST. LOUIS DISTRICT POTAMOLOGY STUDY (LL-I)

(*b*) Department of the Army, St. Louis District, Corps of Engineers.
(*c*) Glendon T. Stevens, Jr.
(*d*) Experimental.
(*e*) Investigation of problems associated with ice conditions and recommendation of possible sources for maintaining navigable channels during the winter season.
(*f*) Completed.

098-11011-860-13

MERAMEC RIVER BASIN WATER SUPPLY STUDY

(*b*) Department of the Army, St. Louis District, Corps of Engineers.
(*c*) Paul R. Munger.
(*d*) Applied research.
(*e*) Assessment of water supply resources of basin and determination of demands at 10-year intervals for 100 years to determine alternatives for providing anticipated water needs.
(*f*) Completed.
(*h*) Completed Master's Thesis, Glendon Stevens III.

098-11012-300-13

NEW ORLEANS DISTRICT POTAMOLOGY STUDY

(*b*) Department of the Army, New Orleans District, Corps of Engineers.
(*c*) Jerome A. Westphal.
(*d*) Applied research.
(*e*) Documentation of historical morphological characteristics of Lower Mississippi River and Atchafalaya River to make comparisons of these at selected time periods.
(*g*) Master's thesis pending.

098-11013-870-60

AN ENGINEERING STUDY OF THE ST. FRANCOIS COUNTY TAILINGS/LANDFILL IN RELATION TO ASSOCIATED THREATS TO THE ENVIRONMENT

(*b*) Missouri Department of Natural Resources.
(*c*) Jerome A. Westphal.
(*d*) Field investigation.
(*e*) To undertake field investigation and develop favorable engineering alternatives for stabilizing tailings pile resulting from iron mining in southeast Missouri.

098-11014-820-36

SURFACE IMPOUNDMENT ASSESSMENT FOR THE STATE OF MISSOURI

(*b*) U.S. Environmental Protection Agency.
(*c*) Jerome A. Westphal.
(*d*) Applied research.

(*e*) To detail the potential for groundwater pollution resulting from surface impoundment of wastewater and hazardous liquid waste in the State of Missouri.

098-11015-860-36

IDENTIFYING NONCOMMUNITY WATER SUPPLY SYSTEMS FOR MISSOURI

(*b*) U.S. Environmental Protection Agency.
(*c*) Gordon E. Weiss.
(*d*) Field investigation and operation.
(*e*) Identification of all noncommunity water supplies–potential future study of water quality related thereto.

098-11016-210-75

SURGE ANALYSIS FOR A WELL FIELD NETWORK

(*b*) Camp, Dresser and McKee.
(*c*) Charles D. Morris.
(*d*) Applied research.
(*e*) Development of a computer program to analyze pipe networks for the effects of hydraulic transients and control equipment.

MONTANA STATE UNIVERSITY, College of Engineering, Department of Agricultural Engineering, Bozeman, Mont. 59715. Professor W. E. Larsen, Department Head.

099-11017-840-00

REFINEMENT OF PUMP IRRIGATION SYSTEM DESIGN FOR CONSERVATION OF ENERGY

(*b*) Montana Agricultural Experiment Station.
(*c*) Professor C. C. Bowman.
(*d*) Field investigation of existing systems and applied research.
(*e*) Field investigations are being made to determine the areas of design which contribute to high head losses. Once the areas are isolated recommendations will be made for correction. Publications will be used to help minimize poor designs and the conservation of energy by better designs.

UNIVERSITY OF NEBRASKA-LINCOLN, Department of Mechanical Engineering, Lincoln, Nebr. 68588. Alexander R. Peters, Professor and Chairman.

101-11019-140-54

AN EXPERIMENTAL INVESTIGATION OF FORCED, FREE, AND COMBINED CONVECTION IN A ROTATING SPHERICAL ANNULUS

(*b*) National Science Foundation, Heat Transfer Program.
(*c*) Dr. Rodney W. Douglass, Asst. Professor.
(*d*) Experimental; basic research; Master's thesis.
(*e*) Research consists of an experimental investigation of the convective motion and heat transfer within a spherical annulus formed by two concentric spheres rotating coaxially with constant, but not necessarily equal, angular velocities. The spherical surfaces are maintained at constant, but unequal, temperatures and a uniform gravitational field acts parallel to the axis of rotation. Conditions ranging from natural convection (stationary spheres) to forced convection and combined natural-forced convection (rotating spheres) are investigated. The geometry allows the important convective processes including natural and forced convection, secondary flows, creeping flow characteristics, boundary layer flow characteristics, and rotating flow characteristics. Results include flow visualization and total heat transfer rate data.

101-11020-140-00

MIXED CONVECTION IN A ROTATING SPHERICAL ANNULUS

(*c*) Dr. Rodney W. Douglass, Asst. Professor. Robert Dallman, Research Engineer, TSB, EG&G, Idaho, Inc., P.O. Box 1625, Idaho Falls, Idaho 83401.
(*d*) Theoretical; basic research; Master's thesis.
(*e*) The steady combined convection of a Boussinesq fluid enclosed between two concentric rotating spheres is analytically investigated. The spheres rotate at constant rates and are maintained at uniform, but unequal temperatures. A uniform gravity field acts parallel to the rotation axis. The governing equations are solved using two approximate methods: a perturbation method valid for small Reynolds numbers and a partial spectral expansion method. The partial spectral expansion method provides solutions for Reynolds numbers nearly two orders of magnitude larger than those for the perturbation method.
(*f*) Completed.
(*g*) Results include streamline, angular velocity and temperature distributions. The effects of the various dimensionless parameters on the flow field and on the heat transfer rates are discussed. Plots of local and total heat transfer rates as well as the torque required to rotate the spheres are shown. The general nature of the flow field is shown to depend on the angular velocity ratio, the Reynolds number, the Prandtl number, and the Grashof number (presented in the ratio Gr/Re^2). Increasing any or all of these parameters causes enhanced convective heat transfer and an increase in the torque. The secondary flow field is strongly dependent on the ratio Gr/Re^2, approaching the single-eddy pattern of natural convection as Gr/Re^2 becomes large. It is shown that the total heat transfer rate and the torque required to rotate the spheres are both independent of the sign of the Grashof number.

101-11021-000-00

VISCOUS FLOW IN OSCILLATORY SPHERICAL ANNULI

(*c*) Dr. Rodney W. Douglass, Asst. Professor.
(*d*) Theoretical; basic research; neither.
(*e*) Theoretical results are presented describing viscous incompressible flow in spherical annuli. The solution is found from a regular perturbation expansion. The character of the flow depends strongly upon the dimensionless frequency of oscillation and the amplitude ratio of the oscillations of the bounding spherical surfaces. The secondary flow can be either "inwardly" or "outwardly" centrifuging, depending on the parameter values.
(*f*) Completed.
(*h*) **Viscous Flow in Oscillatory Spherical Annuli,** B. R. Munson, R. W. Douglass, *Physics of Fluids* **22,** 2, pp. 205-208, Feb. 1979.

UNIVERSITY OF NEVADA RENO, Max C. Fleischmann College of Agriculture, Division of Plant Soil and Water Science, Reno, Nevada 89557. Dewayne E. Gilbert, Chairman.

102-11018-840-00

OUTFLOW, QUANTITY AND QUALITY FROM SUBSURFACE DRAINS

(*c*) Dr. J. C. Guitjens, Professor, Irrigation Engineering.
(*d*) Field investigation; applied/basic; M.S. thesis.
(*e*) 1.5 acre fields will be flood and sprinkler irrigated at three water allotment levels. One level will consist of adequate irrigation to satisfy unrestricted evapotranspiration; the other two levels will consist of smaller irrigation amounts. Quality and quantity of drainage outflow from a system of subsurface drains will be monitored to evaluate the influence of an integrated water management program. Scheduling of water deliveries to the fields will be based on predicted weekly evapotranspiration and actual weekly water balances of three lysimeters.

UNIVERSITY OF NEW ORLEANS, School of Engineering (Civil Engineering), New Orleans, La. 70122. Dr. K. L. McManis, Coordinator.

103-11022-070-00

FLOW OF FLUIDS IN GRANULAR BEDS

(*b*) Office of Research and Development, UNO.
(*c*) Dr. A'Alim A. Hannoura and Dr. Kenneth L. McManis.
(*d*) Experimental study of flow in granular beds.
(*e*) The effect of grain friction on the flow resistance is considered in order to develop a dimensionless Moody diagram type plot for flow in granular beds.

103-11023-430-87

WAVE MOTION IN ROCKFILL

(*b*) National Research Council of Canada.
(*c*) Dr. A'Alim A. Hannoura and John A. McCorquodale (Univ. of Windsor, Ont., Canada).
(*d*) Experimental and numerical studies of wave motion in rockfill embankments.
(*e*) Numerical methods were applied to develop a numerical model for wave motion in layered rubble-mound breakwaters. Experimental studies were carried to estimate the effect of internal breaking on the wave transmission, virtual mass coefficiency and instantaneous pressure on the u/s slope of the breakwater due to wave impact.
(*f*) Completed.
(*g*) A Finite Difference–Finite Element Model was developed to simulate the internal wave motion in layered breakwaters, assuming impervious core.
(*h*) **Air-Water Flow in Coarse Granular Media,** *J. Hyd. Div., ASCI* **104,** HY7, pp. 1001-1010, July 1978.
Unsteady Flow in Porous Media Solved by Combined Fine Element Method of Characteristics Model, *Proc. Intl. Conf. Application of Finite Element Method in Water Resources,* London, England, July 1978.
Virtual Mass of Coarse Granular Media, *J. Waterways, Harbors and Coastal Engrg. Div., ASCE* **104,** WW2, pp. 191-200, May 1978.
Hydraulic Conductivity of Rockfill, *J. Intl. Assoc. for Hyd. Res., IAHR* **2,** pp. 123-137, 1978.

THE CITY COLLEGE OF THE CITY UNIVERSITY OF NEW YORK, School of Engineering, Department of Civil Engineering, Fluid Mechanics Laboratory, New York, N.Y. 10031. Professor Norman C. Jen, Laboratory Director.

104-06185-220-00

CHANGES IN INITIATION OF SEDIMENT MOTION DUE TO FLOW OBSTRUCTION BY PIERS OR SILLS

(*c*) Dr. Walter Rand.
(*d*) Theoretical and experimental; applied research; Master's thesis.
(*e*) If hydrodynamic forces acting on an erodible bed reach values at which sediment motion is impending, a critical or threshold condition is reached. A structure (a pier or sill), if placed in the channel will change flow conditions, and erosion will develop. The principles of sediment transportation mechanics are used, and experiments with sediment beds of impending motion are conducted, to determine the erosion characteristics as functions of the geometry of the structure, and of the degree of obstruction. Using impending motion conditions as a reference, similarity laws for the erosion pattern will be developed.
(*f*) This work has been discontinued.
(*g*) Preliminary experiments with a rectangular channel indicate that the erosion length downstream of sills is a function of the Froude number, provided the impending motion conditions are used as reference.

104-06186-360-00

A FLEXIBLE APPROACH TO THE DESIGN OF STILLING BASINS

(*c*) Dr. Walter Rand.
(*d*) Theoretical, experimental; development, design.
(*e*) Adopting a generalized concept, a spillway-stilling basin complex can be considered as consisting of an entrance structure, a main basin and an after-basin. The present knowledge on flow under gates and over drop structures, spillways, sills, steps, and baffles is applied to development of a design method in which the design of each structural element is determined individually to achieve the best possible solution for a particular set of conditions. The method would be an extension of current design methods for hydraulic jump stilling basins applicable to cases such as very low tail water, intermittent operation, and rocky channels where the current methods do not offer straightforward solutions. Models are used for verification as the design is evolved.
(*f*) The project has been completed and all apparatus disassembled.
(*g*) The approach has been used to analyze some of the current design methods. The agreements found and the interpretations of the current methods indicate that further progress is possible. These analyses are published in (h).
(*h*) Discussion of **The Hydraulic Design of Stilling Basins,** W. Rand, *ASCE Proc.* **84,** Paper 1616, Apr. 1958.
Discussion of **Straight Drop Spillway Stilling Basin,** *J. Hyd. Div., ASCE* **92,** HY1, Jan. 1966.

104-07055-870-00

WATER POLLUTION-DISPERSION AND TRANSPORT PROCESS ALONG A COAST

(*c*) Professor Norman C. Jen and Dr. F. F. Yeh.
(*d*) Experimental; applied research; for Master's thesis.
(*e*) By simulating an actual condition along a coast, the processes of dispersion and transport of dissolved and/or other particles are considered to be important for water pollution problems. The waves, winds and current can be introduced separately or combined together. The test tank is 20 ft by 10 ft and 2 ft in depth.
(*f*) The work was completed. The thesis was accepted. The apparatus has been disassembled.

104-08164-870-00

HOT TURBULENT DISCHARGE INTO UNIFORM OR DENSITY STRATIFIED ENVIRONMENT

(*c*) Professor Norman C. Jen and Andrew H. Wojtkowski.
(*d*) Experimental and theoretical; applied research; Ph.D. thesis.
(*e*) The process of thermal discharges into uniform or density stratified environment is being simulated. The data of temperature, velocity and turbulence intensity distribution are taken for various flow conditions and discharge nozzle locations. Parallel to the experimental research numerical and analytical work is being conducted. Investigation has an immediate application to water thermal pollution problems.
(*f*) The project has been completed and the dissertation has been accepted.

NEW YORK OCEAN SCIENCE LABORATORY of Affiliated Colleges and Universities, Incorporated, Edgemere Road, Montauk, N.Y. 11954. John C. Baiardi, President and Director.

105-11024-450-60

OCEANOGRAPHY OF THE PECONIC BAY SYSTEM

(*b*) New York State.
(*c*) Dr. Rudolph Hollman.
(*d*) Field investigation/applied research.

(*e*) A study of the water budget, circulation, and physical properties of the waters of the Peconic Bay System comprising Little and Great Peconic Bays, and Flanders Bay.
(*g*) Preliminary results indicate that the balance of waters in the bay system is a result of a complex interaction between tidal currents, winds, stream discharges, and groundwater seepage. A two-dimensional time dependent finite element model is being applied to this system of bays.

105-11025-450-60

OCEANOGRAPHY OF EASTERN LONG ISLAND AND BLOCK ISLAND SOUND

(*b*) New York State.
(*c*) Dr. Rudolph Hollman.
(*d*) Field investigation, experimental, applied research.
(*e*) Study involves seasonal, diurnal, and tidal variations of physical parameters in Block Island Sound and eastern Long Island Sound and their response to atmospheric forcing, the mixing and exchange characteristics of these waters, and general circulation of these waters. This study is coupled to a mathematical model of the circulation and dispersion of the area. An auxillary study of meteorological parameters including wind speed and direction, pressure, temperature, humidity, evaporation, and solar radiation is also being carried out.
(*g*) Analysis to date indicates a mean daily rate of heat gained by these waters between the end of February and the end of August to be 0.089 cal/cm^3-day. Maximum rate of heat loss to the water occurs between January and February (approximately 0.18 cal/cm^3-day) with a secondary maximum in heat loss occurring between October and November (0.12 cal/cm^3-day). Turbulent conductivity coefficients based on a Fourier analysis of annual temperature data at 5 levels in the water of Block Island Sound indicate a fairly low level of turbulent activity.

POLYTECHNIC INSTITUTE OF NEW YORK, Aerodynamics Laboratories, Route 110, Farmingdale, N.Y. 11735. Professor M. H. Bloom, Director.

106-09893-740-50

COMPUTATIONAL FLUID DYNAMICS

(*b*) National Aeronautics and Space Administration, Air Force Office of Scientific Research.
(*c*) Professor Stanley G. Rubin.
(*d*) Basic theoretical research; Masters theses.
(*e*) In order to increase computational efficiency for viscous flow calculations, higher-order polynomial (spline) methods have been applied to laminar and turbulent boundary layer flows, as well as the incompressible Navier-Stokes equations. The laminar flow in a rectangular inlet has been critically examined in order to accurately determine the secondary motion and demonstrate a predicted Reynolds number independence principle.
(*h*) **Laminar Flow in Rectangular Channels. Part I–Entry Analysis. Part II–Numerical Solution for a Square Channel,** S. G. Rubin, P. K. Khosla, S. Saari, *J. Computers and Fluids* **5**, 3, pp. 151-173, Sept. 1977.
Polynomial Interpolation Methods for Viscous Flow Calculations, S. G. Rubin, P. K. Khosla, *J. Comp. Physics* **24**, pp. 217-244, 1977.
Turbulent Boundary Layers With and Without Mass Injection, S. G. Rubin, P. K. Khosla, *Computers and Fluids* **5**, pp. 241-259, Dec. 1977.

106-09894-630-52

VORTEX AUGMENTOR CONCEPT FOR WIND ENERGY CONVERSION

(*b*) U.S. Dept. of Energy and the Solar Energy Research Institute.
(*c*) Professor P. M. Sforza.
(*d*) Experimental, theoretical, and field investigation, applied research and design.
(*e*) Research design, and development on aerodynamic devices which can concentrate and augment natural winds is being performed. The keystone element is the generation and control of discrete vortices of high power density by the appropriate interaction of suitably designed aerodynamic surfaces with natural winds of low power density. Properly configured turbines are utilized to transform the energy in this compacted vortex field to useful shaft work. This idea is termed the Vortex Augmentor Concept (VAC, patent pending).
(*g*) Concept has now proceeded to the field test stage. An extensive field test facility for wind engineering studies has been erected and tied into a computer system for data acquisition and processing. A fully instrumented prototype of the Vortex Augmentor Concept (patented and patents pending) is currently being tested at the field test station.
(*h*) **An Experimental Facility for Wind Engineering Research,** P. M. Sforza, et al., *AIAA 10th Aerodynamic Testing Conf., AIAA Paper No. 78-813*, Apr. 1978.
Wind Power Distribution, Control, and Conversion in Vortex Augmentors, P. M. Sforza, W. Stasi, in *Fluid Engineering in Advanced Energy Systems*, C. H. Marston (editor) ASME, 1978.
Wind Turbine Generator Wakes, P. M. Sforza, et al., *AIAA 17th Aerospace Sciences Mtg., AIAA Paper No. 79-0113*, Jan. 1979.

106-09895-700-50

LASER DIAGNOSTICS

(*b*) National Aeronautics and Space Administration, Office of Naval Research, National Science Foundation.
(*c*) Professor S. Lederman.
(*d*) Basic experimental research, Masters and Ph.D. theses.
(*e*) The development of nonintrusive diagnostic techniques in flow fields is the aim of this work. The techniques investigated are the spontaneous Raman diagnostics for concentration and temperature measurements, Laser Doppler Anemometry for velocity and turbulence measurements, Brillouin scattering for flow field fluctuation measurements, Laser Doppler Anemometry for velocity and turbulence measurements, Brillouin scattering for flow field fluctuation measurements, and Coherent Anti-Stokes Raman Scattering for concentration and temperature measurements in situations where the spontaneous Raman may not be applicable. The aforementioned diagnostic techniques are applied to coaxial turbulent jets, flames and combustion, both high and low pressure.
(*h*) **Experimental Techniques Applicable to Turbulent Flows,** S. Lederman, *AIAA Paper 77-213, AIAA 15th Aerospace Sciences Mtg.*, Los Angeles, Calif., Jan. 1977.

106-09896-720-60

STRATIFIED FLOW AND RELATED ENVIRONMENTAL WIND-TUNNEL FACILITIES

(*b*) New York State Science and Technology Foundation, Advance Research Projects Agency, New York City Fire Department.
(*c*) Professor. M. H. Bloom.
(*d*) Experimental research of basic and applied nature.
(*e*) Development and calibration of a thermally stratified wind-tunnel of 4 × 5 ft cross-section to provide simulation of atmospheric boundary layers and of the ocean thermocline. In the unstratified mode the wind-tunnel serves as a conventional low-speed facility. Research involved turbulent wake behavior in stratified ocean regions, flow around urban building systems relevant to internal fume control within high-rise buildings, and internal flows in high rise buildings for fire control.

106-09897-010-50

WING-BODY AERODYNAMICS

(*b*) Air Force Office of Scientific Research.
(*c*) Professor S. G. Rubin.

(*d*) Basic and applied theoretical and experimental research.
(*e*) Boundary layer interactions and secondary motion due to wing-tail assemblies have been examined with a viscous slender body theory. Effects of different geometries and small incidence angles are considered in order to predict possible separation and vortex phenomena near edges and corners. Wing-body interference effects are evaluated by vortex lattice techniques. Large angles of attack are to be considered by using a modified finite-step method. Span loadings are to be evaluated at subsonic speeds. The effects of high lift devices, rotary motion, interference and multipanel wings are under investigation.
(*h*) **Boundary Layer Induced Crossflow Due to Wing-Body Interference,** S. G. Rubin, J. M. Lyons, *Proc. 17th Aerospace Sciences Mtg., AIAA Paper No. 79-0140*, New Orleans, La., Jan. 15-17, 1979.

POLYTECHNIC INSTITUTE OF NEW YORK, Department of Civil and Environmental Engineering, 333 Jay Street, Brooklyn, N. Y. 11201. Henry F. Soehngen, Professor and Department Head.

107-09947-820-80

AUGMENTATION OF LOW STREAMFLOWS FROM GROUNDWATER

(*b*) Delaware River Basin Commission.
(*c*) Dr. Alvin S. Goodman, Professor.
(*d*) Theoretical, applied research.
(*e*) Estimate of potential for low flow augmentation in the Delaware River Basin by development and operation of groundwater reservoirs in zones of stratified drift which are contiguous with surface streams. Employs groundwater finite-difference mathematical modeling to test pumping arrangements and strategy for operation. Includes cost estimates and review of potential environmental and institutional issues.
(*f*) Completed, October 1978.
(*g*) Maximum potential yield was estimated at 1730 cfs. Investment cost $2.9 million for average augmentation of 9.0 cfs over 90 days in moderately high yield areas. Review did not reveal any serious general environmental or institutional problems. Program of continued studies was recommended.
(*h*) **Groundwater Pumping for Streamflow Augmentation,** A. S. Goodman, M. L. Thatcher, R. R. Zavesky, *Proc. ASCE WRPM Specialty Conf. on Water Systems 1979*, Houston, Feb. 25-28, 1979.
Emergency Water Supplies from Groundwater in Humid Regions, S. Bagchi, A. S. Goodman, accepted for publication, Am. Water Resources Assn.
Augmentation of Low Streamflows from Groundwater, A. S. Goodman, M. L. Thatcher, R. R. Zavesky, Polytechnic Inst. N. Y., Oct. 1978.
Water Supplies from Groundwater for Thermal Power Plants, A. S. Goodman, S. Bagchi, M. P. Bromstein, *Symp. Hydraulics and Water Resources and Management Divisions of ASCE*, Pittsburgh, Apr. 1978.
Copy of thesis will be available through University Microfilms.

107-09948-870-60

CORRELATION OF MATHEMATICAL MODELS FOR WATER TEMPERATURE WITH AERIAL INFRARED WATER TEMPERATURE SURVEYS

(*b*) New York State Energy Research and Development Authority.
(*c*) Dr. Alvin S. Goodman, Professor (Principal Investigator–Dr. Joseph C. Cataldo, Cooper Union, New York 10003).
(*d*) Theoretical, applied research.
(*e*) In Phases I, II and III, a technique was developed and tested to predict subsurface temperatures from surface isotherms obtained from overflight IR measurements. A model was also developed and tested to determine a three-dimensional plume structure by using only discharge parameters. Current Phase IV work includes a user's manual, use of phenomenological model, orientation program for utilization and application, and detailed study of thermal fronts.
(*g*) Models developed in Phases I, II and III were tested successfully, with average accuracy of predictions within 0.25 °C with standard deviation of 0.50 °C.
(*h*) **Studies of Thermal Electric Power Plant Heated Discharges–Phase III–Development and Testing of Three-Dimensional Plume Models and Investigation of Thermal Fronts,** J. C. Cataldo, A. S. Goodman, Polytechnic Inst. of N.Y., Aug. 1978.
A Three-Dimensional Thermal Plume Model, J. C. Cataldo, R. R. Zavensky, A. S. Goodman, *Hydraulic Div. Specialty Conf., ASCE*, Univ. of Maryland, Aug. 9-11, 1978.
Prediction of Temperature Due to Heated Discharges, J. C. Cataldo, R. R. Zavesky, A. S. Goodman, *J. Power Div., ASCE*, Apr. 1978.

107-09949-340-60

MULTIFARIOUS WATER INTAKE STRUCTURE–PHASE II–RESEARCH AND DEVELOPMENT PLAN

(*b*) New York State Energy Research and Development Authority.
(*c*) Dr. Alvin S. Goodman, Professor.
(*d*) Theoretical, applied research and design.
(*e*) Revised layout and further studies of intake structures for thermal power plant to improve biological performance. This phase includes recommendations for physical and biological testing.
(*f*) Completed, August 1978.
(*g*) Approximate construction and installation cost would be $9.50 to $15 per kilowatt. Savings would be 67-80 percent if use of MWIS would permit open-cycle instead of closed-cycle cooling systems. Total hydraulic, biological and field testing program would cost $145,000 to $410,000 not including Polytechnic engineering.
(*h*) **Development of a Water Intake Structure to Reduce Adverse Effects on Aquatic Ecology,** A. S. Goodman, M. L. Thatcher, U. Kanik, *Intl. Symp. Environmental Effects of Hydraulic Works*, Knoxville, Tenn., Sept. 12-14, 1978.
Studies of Multifarious Power Plant Water Intake Structure–Phase II–Research and Development Plan, A. S. Goodman, Polytechnic Inst. of N.Y., Aug. 1978.

107-09950-810-00

PREDICTION OF FLOOD DISCHARGES FROM WETLANDS

(*c*) Dr. Alvin S. Goodman, Professor.
(*d*) Theoretical, applied research; for Doctoral thesis.
(*e*) Formulation and testing of a mathematical model using correlation techniques, to predict flood discharges from wetland areas, considering effects of future land development.

107-11061-870-00

USE OF SPECTRAL ANALYSIS TO DESCRIBE THE VARIANCE OF DISSOLVED OXYGEN WITHIN A TIDAL RIVER

(*c*) Dr. Alvin S. Goodman, Professor.
(*d*) Theoretical; applied research; for Doctoral thesis.
(*e*) Model has been developed to access the impact of diverse waste discharges upon the marine environment. The receiving water system is described in terms of its frequency transfer characteristics which are based on flow, dispersion, geometry and reaction kinetics. The waste inputs are characterized singly by means of the distribution of their variance with frequency obtained by using the techniques of spectral analysis as well as collectively in terms of cross-spectral relations. Special attention is given to the effects of combined sewer overflows upon the receiving water variance of dissolved oxygen.

(g) Model predictions are compared with in situ monitor data in the Delaware River. Model results are also compared with those of recently derived analytical solutions.

107-11062-450-65

REVIEW OF HISTORICAL, HYDRAULIC AND SALINITY DATA OF GREAT SOUTH BAY, LONG ISLAND, N.Y. AND ANALYSES OF THE BAY's SALINITY RESPONSE WITH FOCUS ON TIDAL INLET GEOMETRY AND HYDRODYNAMICS

(b) Suffolk County Dept. of Environmental Control.
(c) Dr. M. Llewellyn Thatcher, Associate Research Professor (or Dr. Rudolph Hollman, N.Y. Ocean Science Laboratory).
(d) Theoretical; applied research.
(e) Compilation of data base covering salinity, tidal range, and other parameters. Statistical analyses to evaluate various hypotheses of salinity response to factors such as tidal range, stream discharge, storm runoff, and inlet configurations. Numerical hydraulic model applied to evaluate the hydraulic response of the bay to historical geometry changes in the inlet, which are translated into the salinity response for the bay.

107-11063-340-60

HYDROELECTRIC POWER INVENTORY AND RELATED RESEARCH PROGRAM

(b) N.Y. State Energy Research and Development Authority.
(c) Dr. Alvin S. Goodman, Professor.
(d) Field and office investigation; applied research.
(e) Development and maintenance of Hydroelectric Power Data Base. Identification and analyses of procedures for project development. Evaluation of prospects for development. Studies of N.Y. State Barge Canal System for multipurpose use with focus on hydropower.
(g) 468 sites with dams and 286 sites currently without dams have combined potential capacity of 3000 Megawatt.
(h) **Small Hydropower Projects in New York State,** A. S. Goodman, M. L. Thatcher, R. S. Brown, *Preprint 3549 ASCE Convention*, Boston, Apr. 2-6, 1979.
An Assessment of Hydropower Restoration and Expansion in New York State, R. S. Brown, A. S. Goodman, Polytechnic Inst. of N.Y., Aug. 1978.
Status of Small Hydropower Studies in New York State, R. S. Brown, R. Napoli, A. S. Goodman, M. L. Thatcher, in *Low Head Hydro*, J. S. Gladwell, C. C. Warnick, Editors, Univ. of Idaho, Sept. 1978.

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STATE UNIVERSITY OF NEW YORK AT BUFFALO, Department of Chemical Engineering, Buffalo, N.Y. 14260. Dr. J. J. Ulbrecht, Professor and Department Chairman.

108-11601-120-00

FLUID MECHANICS OF NON-NEWTONIAN LIQUIDS

(c) Jaromir J. Ulbrecht, Principal Investigator.
(e) Laser-Doppler anemometry is used to investigate three classes of laminar non-viscometric flows of rheologically complex liquids: the flow in helical coils, the converging drag flow, and the flow around a spinning disc.

108-11602-120-00

BUBBLE FORMATION AND COALESCENCE IN RHEOLOGICALLY COMPLEX MEDIA

(c) Jaromir J. Ulbrecht, Principal Investigator.
(e) The role of viscoelasticity and variable viscosity on the growth and detachment of gas bubbles from a nozzle is studied both theoretically and experimentally.

108-11603-130-00

FLUID AND PARTICLE MECHANICS OF LIQUID DISPERSIONS

(c) Jaromir J. Ulbracht and Pieter Stroeve.
(e) A fast image analyzing computer is used to investigate the behavior of individual liquid particles under well-defined shear.

108-11604-130-00

FLUID MECHANICS OF INJECTION AND EXTRUSION BLOW MOLDING PROCESSES

(c) Michael E. Ryan.
(e) The governing equations of motion are solved both in closed-form under certain simplifying assumptions as well as numerically for two types of flow. Experimental data are obtained both for thermoplastics as well as for thermosets.

108-11605-020-00

MODELING OF LAMINAR FLOWS IN MOTIONLESS MIXERS

(c) Jaromir J. Ulbrecht, Principal Investigator.
(e) A network model of flow was developed for one sandwich of a motionless (static) mixer. It allows to predict both temporal as well as spatial distribution functions.

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STATE UNIVERSITY OF NEW YORK AT BUFFALO, Department of Civil Engineering, Buffalo, N.Y. 14214. Professor W. W. Recker, Acting Chairman.

109-09966-410-44

PHYSICAL AND ECONOMIC STATUS OF STRAWBERRY ISLAND

(b) Sea Grant Program, NOAA, Dept. of Commerce.
(c) Dale D. Meredith, Professor.
(d) Field investigation, applied research, Masters thesis.
(e) Determine if protective measures are necessary to preserve Strawberry Island from loss by erosive activity and to examine various alternative protective devices as to their effectiveness and cost.

109-09967-420-44

EFFECT OF AN OFFSHORE BARRIER UPON THE WAVE-HEIGHT DISTRIBUTION IN A HARBOR

(b) Sea Grant Program, NOAA, Dept. of Commerce.
(c) Dr. Volker W. Harms, Asst. Professor.
(d) Theoretical, applied research, Masters thesis.
(e) The boundary value problem associated with the diffraction of water waves will be solved by a technique based upon the method of Green Functions that is applicable to cylindrical structures of arbitrary cross-sectional geometry.

109-09968-860-33

OPTIMAL OPERATION RULES FOR MULTI-RESERVOIR WATER RESOURCES SYSTEMS

(b) Office Water Research and Technology, Dept. of the Interior.
(c) Dale D. Meredith, Professor.
(d) Theoretical, applied research.
(e) To formulate, refine, and demonstrate methodologies for determining optimal operation rules for multiple purpose, multireservoir systems with stochastic inflows.
(h) **Water Resources Modeling and Optimization Based on Conservation and Flooding Pools,** *Discussion*, D. D. Meredith, *Water Resources Bulletin*, *AWRA* **14,** 6, pp. 1510-1511, Dec. 1978.

109-09969-440-44

OPERATING RULES FOR REGULATION OF GREAT LAKES WATER LEVELS

(*b*) Sea Grant Program, NOAA, Dept. of Commerce.
(*c*) Dale D. Meredith, Professor.
(*d*) Theoretical, applied research.
(*e*) Develop a methodology for determining optimal regulation rules for Lake Ontario.

109-09970-410-44

HYDRAULIC AND SEDIMENTATION ANALYSIS OF SALMON RIVER INLET

(*b*) Sea Grant Program, NOAA, Dept. of Commerce.
(*c*) Dale D. Meredith, Professor.
(*d*) Theoretical with field investigation, applied research.
(*e*) To ascertain the relative importance of river flows, waves, and longshore currents in determining the sediment budget and morphology of the spit, inlet and lower Salmon River channel.

109-11026-870-70

FREQUENCY ANALYSIS FOR INDUSTRIAL STORMWATER DETENTION BASINS

(*b*) Koppers Company, Inc.
(*c*) Dale D. Meredith, Professor.
(*d*) Theoretical, applied research for design.
(*e*) Determine procedure for design stormwater detention basins for industrial plant sites based on rainfall frequency and stormwater treatment rates.

109-11027-860-00

ANALYSIS AND OPTIMIZATION OF WATER DISTRIBUTION SYSTEMS

(*c*) Dale D. Meredith, Professor.
(*d*) Theoretical, applied research, Master's thesis.
(*e*) Develop procedure for determining optimum pipe diameters for a given water distribution network.

109-11028-870-00

EFFECT OF PRIMARY SETTLING TANK EFFICIENCY ON THE OPTIMAL DESIGN OF THE ACTIVATED SLUDGE WASTEWATER TREATMENT PROCESS

(*c*) Dale D. Meredith, Professor.
(*d*) Theoretical, applied, Master's thesis.
(*e*) To determine the effect of the primary settling tank efficiency on the design of activated sludge wastewater treatment plant design.

109-11029-050-00

DYNAMICS OF TWO-DIMENSIONAL BUOYANT SURFACE JET OVER SLOPING BOTTOM

(*c*) B. Safaie.
(*d*) Experimental and basic.
(*e*) Obtain a better understanding of the dynamics of buoyant surface jets with the existence of solid sloping boundary through a systematic set of experiments. The results will be used to develop design guidelines for thermal discharges and development of theoretical model.

109-11030-440-44

ICE TRANSPORT BY WIND AND WAVES IN THE GREAT LAKES

(*b*) Great Lakes Environmental Research Laboratory; National Oceanic and Atmospheric Administration, Department of Commerce.
(*c*) Ralph R. Rumer, Professor.
(*d*) Theoretical and experimental applied research.
(*e*) Project aims at elucidating the physics of ice transport processes; inventorying available data and establishment of data base for application of theory, and the development of ice transport forecasting methods for application to the Great Lakes.
(*h*) **Dynamics of Ice Transport in Large Lakes,** R. Rumer, R. Crissman, A. Wake. Contract No. 03-6-022-352636, GLERL, NOAA, Dept. of Commerce, Ann Arbor, Mich.
Effect of Surface Meltwater Accumulation on the Dissipation of Lake Ice, A. Wake, R. Rumer, *Water Resources Research*, in press.
Modeling Ice Dissipation in Eastern Lake Erie, R. Rumer, P. Yu, *J. Great Lakes Research* 4(2), pp. 194-200, 1978.

109-11031-430-44

DEVELOPMENT OF DESIGN CRITERIA FOR FLOATING TIRE BREAKWATER

(*b*) Sea Grant Program, NOAA, Dept. of Commerce.
(*c*) Volker W. Harms, Asst. Professor.
(*d*) Theoretical and experimental, applied research.
(*e*) Develop design criteria for floating tire breakwater for use as energy dissipators as low-cost wave-protection structures.
(*h*) **Preliminary Report on the Application of Floating-Tire-Breakwater Design Data,** V. W. Harms, T. J. Bender, *Water Resources and Environmental Engrg. Research Rept. No. 78-1*, Dept. of Civil Engrg., State Univ. of N.Y. at Buffalo, Buffalo, N.Y., 55 pages, Apr. 1978.
Data and Procedures for the Design of Floating Tire Breakwater, V. W. Harms, *Water Resources and Environmental Engrg. Research Rept. No. 79-1*, Dept. of Civil Engrg., State Univ. of N.Y. at Buffalo, Buffalo, N.Y., 115 pages, Jan. 1979.

STATE UNIVERSITY OF NEW YORK AT BUFFALO, Department of Engineering Science, Aerospace Engineering and Nuclear Engineering, Buffalo, N. Y. 14214. Dr. Richard P. Shaw, Professor.

111-11032-450-00

TRANSPORT PROCESSES IN OCEANS AND LAKES

(*e*) Report on various research projects.
(*d*) Proceedings of symposium.
(*f*) Completed.
(*h*) Plenum Press, 1977, Coordinating Ed. R. J. Gibbs.

111-11033-470-20

"FEBIE"–A COMBINED FINITE ELEMENT–BOUNDARY INTEGRAL EQUATION APPROACH

(*b*) ONR.
(*d*) Theoretical, basic research application to harbor resonance of new method combining finite elements and boundary integral equations.
(*f*) Suspended.
(*g*) Numerical results good for simple case. Future development planned.
(*h*) Presented *Intl. Symp. on Innovative Numerical Analysis in Applied Engineering Science*, Paris, France, May 1977, pp. 1.97-1.101, CETIM, Senlis France. Also *Computers and Fluids* **6**, pp. 153-160, 1978.

111-11034-420-20

LONG WAVES OBLIQUELY INCIDENT ON A CONTINENTAL SLOPE AND SHELF WITH A PARTIALLY REFLECTING COASTLINE

(*b*) ONR.
(*d*) Theoretical, basic research.
(*e*) Analytical solution for long water waves over linear bottom topography.
(*g*) A number of solutions have been obtained for long water wave refraction and reflection from continental shelfs and slopes of linear depth dependence.
(*h*) Presented *IUGG Tsunami Symposium*, Ensenada, Mexico, Mar. 1977, *Manuscript Report Series No. 48*, Dept. of Fisheries and Environment, Ottawa, Canada, pp. 122-130, 1978. An expanded version appears in *Marine Geodesy* **2**, (1), pp. 1-14, 1979.

111-11035-420-20

LONG WAVES ON LINEARLY VARYING BOTTOM TOPOGRAPHY

(b) ONR.
(c) W. Neu.
(d) Theoretical, basic research.
(e) Analytical solution for long water waves over linear bottom topography.
(g) Reflection and refraction of long water waves by linearly varying underwater valleys and ridges have been studied analytically.
(h) Presented *Intl. Symp. Long Waves in Oceans*, June 6-8, 1978, Ottawa, Canada, *Proc. I.S.L.W.O.*, (in press).

111-11036-450-54

THE INTERNATIONAL DECADE OF OCEAN EXPLORATION...AND BEYOND.

(b) NSF.
(c) R. P. Shaw or C. A. Collins, IDOE, NSF.
(d) Descriptive.
(e) Summary of IDOE goals and accomplishments.
(f) Completed.
(g) Summary.
(h) *Marine Geodesy* **2**, (2), pp. 189-195, 1979.

NORTH CAROLINA STATE UNIVERSITY AT RALEIGH, School of Engineering, Department of Mechanical and Aerospace Engineering, Raleigh, N.C. 27607. Professor J. C. Williams III, Associate Department Head.

112-11037-870-60

OCEAN OUTFALL FEASIBILITY STUDY

(b) Coastal Plains Regional Commission and N.C. Department of Administration.
(c) F. Y. Sorrell.
(d) Analytical and numerical study of pollutant transport in North Carolina coastal waters.
(g) Predicted values for pollutant concentration for various discharge locations and rates. Some field data on nearshore currents were obtained and used in the calculation.

112-11038-870-44

METHODOLOGY TO PREDICT MIXING AND DISPERSION FROM OCEAN OUTFALLS

(b) NOAA–Sea Grant Program.
(c) F. Y. Sorrell.
(d) Analytical and numerical study of methods to discharge wastewater in North Carolina coastal waters. Study centers on discharge method, likely discharge parameters and outfall configuration. Discharge plume location, size and effluent concentration are described by a predictive model.
(f) Completed.

112-11039-410-44

MEASUREMENT OF NEARSHORE PHYSICAL PROCESSES

(b) NOAA–Sea Grant Program.
(c) F. Y. Sorrell.
(d) Field study of suitable instrumentation to develop a sensor array in the coastal zone. Objective is to measure nearshore transport processes.

NORTHERN MICHIGAN UNIVERSITY, School of Arts and Sciences, Department of Geography, Earth Science and Conservation, Marquette, Mich. 49855. Jarl Roine, Associate Professor and Head.

113-06053-440-00

DRIFT BOTTLE STUDY OF THE SURFACE CURRENTS OF LAKE SUPERIOR

(c) Dr. John D. Hughes, Professor.
(d) Field investigation; basic research.
(e) To determine the surface current pattern of Lake Superior as it exists during each of the four seasons of the year.
(f) Suspended.
(g) 617 returns from 4845 drifters released (Dec. 1969). One preliminary qualitative paper published in Michigan Academician, Winter 1970.
(h) **Drift Bottle Study of the Surface Currents of Lake Superior,** *Michigan Academician* **III**, 4, Spring 1971. Reprints available from above address.

OAKLAND UNIVERSITY, School of Engineering, Rochester, Mich. 48063. Dr. M. S. Ghausi, Dean of Engineering.

114-11040-130-54

AN EXPERIMENTAL AND THEORETICAL STUDY OF TRANSIENT AND UNSTABLE FLOW PHENOMENA IN TWO-PHASE CONDENSING FLOW SYSTEMS

(b) National Science Foundation, Engineering Division, Mechanical Sciences and Engineering Section, Heat Transfer Program.
(c) Dr. G. L. Wedekind, Professor of Engineering.
(d) Experimental and theoretical; basic research.
(e) Preliminary experimental data indicates that small changes in the inlet vapor flowrate momentarily cause a very large transient surge in the outlet flowrate of the subcooled liquid. Also, under certain operating conditions, the condensing flow system has been observed to develop unstable flow oscillations, where the amplitude of these oscillations tends to grow, reaching a type of limit-cycle. Amplitudes exceeding the mean flowrate have been observed, resulting in flow reversals. The major objectives of the proposed research are to experimentally and theoretically study these transient and instability phenomena, including the effects of compressibility, in an effort to identify the principle physical mechanisms governing them, with the ultimate hope of being able to formulate theoretical models which have the capability of both describing the phenomena, and predicting the influence of various system parameters.
(g) Experimental data have been obtained which indicate that the effects of compressibility of the vapor can considerably alter the transient flow surges which have been observed. These compressibility effects are coupled to the flow resistance in the outlet subcooled liquid.
(h) **An Experimental and Theoretical Investigation into Thermally Governed Transient Flow Surges in Two-Phase Condensing Flow,** G. L. Wedekind, B. L. Bhatt, *J. Heat Transfer* **99**, 4, pp. 561-567, Nov. 1977.

A System Mean Void Fraction Model for Predicting Various Transient Phenomena Associated with Two-Phase Evaporating and Condensing Flows, G. L. Wedekind, B. L. Bhatt, B. T. Beck, *Intl. J. Multiphase Flow* 4, pp. 97-114, 1978.

Transient and Frequency Response Characteristics of Two-Phase Condensing Flows; With and Without Compressibility, *2nd Multi-Phase Flow and Heat Transfer Symp. Workshop*, Miami Beach, Fla., Apr. 16-18, 1979.

OAK RIDGE NATIONAL LABORATORY, P.O. Box X, Oak Ridge, Tenn. 37830. Dr. Herman Postma, Director.

115-10021-340-55

NOISE DIAGNOSTICS FOR SAFETY ASSESSMENT

(*b*) Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission.
(*c*) D. N. Fry, Instrumentation and Controls Division, Bldg. 3500, ORNL, P.O. Box X, Oak Ridge, Tenn. 37830.
(*d*) Experimental: measurement and diagnostics of the fluctuating component (noise) from neutron detectors in nuclear reactors.
(*e*) Provide specialized engineering services (analytical, experimental, and technical review) to NRC in the areas of reactor surveillance, diagnostics, and loose-parts monitoring, making available the broad interdisciplinary skills, extensive reactor instrumentation and measurement science development experience, and advance experimental and analytical capabilities of the Laboratory. These services will aid NRC in evaluating the performance of specific nuclear power plants now in operation and assessing the adequacy of existing noise monitoring and diagnostic techniques; and reviewing and upgrading surveillance instrumentation designs and diagnostic procedures currently in the planning stage. As deemed desirable by NRC, we will perform diagnostic measurements in operating nuclear power plants suspected of anomalous behavior and/or review measurement performed by others; and demonstrate analytical methods by which observable quantities may be related to unobservable physical properties of interest within the nuclear steam supply system.
(*g*) Neutron noise specialists Dwayne Fry and Bob Kryter and their groups, composed of Instrumentation and Controls Division staff and consultants and students from the University of Tennessee, provided measurement and consulting services to the Office of Nuclear Reactor Regulation which resulted in increased power production of BWR-4 reactors. When flow-induced, internal vibrations developed in eleven BWR-4 reactors, NRC requested that ORNL provide technical assistance in diagnosing the problem, determining its safety implications and determining a safe operational power level for each reactor. This generic problem involved excessive vibrations of the instrument tubes that run the length of the core. These tubes were impacting nearby channel boxes, sometimes hard enough and frequently enough to wear holes in the adjacent fuel channel boxes. Since the integrity of the channel boxes must be maintained because of LOCA safety restrictions, NRC had to decide whether to shut down the reactors completely or to allow their operation at reduced power levels. By measuring the frequency spectrum of the fluctuating component (noise) of the signals from neutron detectors already installed inside these detector tubes, we and our colleagues from industry and the affected utilities determined not only which instrument tubes were vibrating but also which ones were impacting the adjacent fuel channel boxes. With this information at hand, the decision could be made to allow continued operation of these eleven reactors at a power level just below the value where channel box impacting occurred until a more thorough corrective action (changing the coolant flow pattern in the core) could be engineered and accomplished. The full impact of our contribution is hard to estimate, but in one particular plant our measurements showed that the reactor could be safely operated at a power level 20 percent higher than the value initially fixed by NRC when the vibration problem was first discovered. This single instance could have more than paid for the cost of research and development associated with ORNL's participation in this problem.

Our involvement is not yet completed. We are now monitoring the performance of reactors that have been modified by the manufacturer and are helping NRC obtain noise signature libraries for LWR primary system sensors so that better historical data will be available if problems of this type reappear.

(*h*) **Summary of ORNL Investigation of In-Core Vibrations in BWR-4s,** D. N. Fry, R. C. Kryter, M. V. Mathis, J. E. Mott, J. C. Robinson, *ORNL/NUREG/TM-101* (1977).

Inference of Core Barrel Motion from Neutron Noise Spectral Density, J. C. Robinson, F. Shahrokhi, R. C. Kryter, *ORNL/NUREG/TM-100* (1977).

Determination of Void Fraction Profile in a BWR Channel Using Neutron Noise Analysis, M. A. Atta, D. N. Fry, J. E. Mott, submitted as Tech. Note to *Nucl. Sci. Eng.* (1977).

Bandwidth-Related Errors in the Inference of PWR Barrel Motion from Ex-Core Neutron Detector Signals, J. C. Robinson, R. C. Kryter, *Trans. Amer. Nucl. Soc.* **24,** 1, pp. 413-415, Nov. 1976.

U.S. Experience with In-Service Monitoring of Core Barrel Motion in PWRs Using Ex-Core Neutron Detectors, R. C. Kryter, J. C. Robinson, J. A. Thie, submitted for presentation *Intl. Conf. on Vibration in Nuclear Plant*, May 9-11, 1978, Keswick, England.

115-10022-340-55

PWR-BLOWDOWN HEAT TRANSFER SEPARATE EFFECTS PROGRAM

(*b*) Nuclear Regulatory Commission.
(*c*) D. G. Thomas.
(*d*) Experimental and analytical applied research.
(*e*) The ORNL Pressurized-Water Reactor Blowdown Heat Transfer (PWR-BDHT) Program is an experimental separate-effects study of the relations among the principal variables that can alter the rate of blowdown, the presence of flow reversal and rereversal, time delay to critical heat flux, the rate at which dryout progresses, and similar time-related functions that are important to LOCA analysis. Primary test results are obtained from the Thermal-Hydraulic Test Facility (THTF), a large nonnuclear pressurized-water loop that incoporates a 49-rod electrically heated bundle. Supporting experiments are carried out in several additional test loops–the Forced Convection Test Facility (FCTF), a small high-pressure facility in which single heater rods can be tested in annular geometry; an air-water loop which is used to evaluate two-phase flow-measuring instrumentation; a transient steam-water loop which is also used to evaluate two-phase flow-measuring instrumentation; and a low-temperature water mockup of the THTF heater rod bundle, containing a large number of pressure taps and conductivity probes to quantify THTF bundle hydraulics using COBRA.
(*g*) Supporting two-phase flow instrumentation studies have shown that accurate reduction of two-phase flow data requires drag disk calibration and use of a two-velocity model; that increased gamma densitometer stability can be achieved by replacing scintillation detectors with high-pressure ionization chambers; that the signal-to-noise ratio of drag disks is substantially increased by replacing the disk with a full flow screen; and that the effective THTF turbine meter time constant may be markedly reduced by replacing the variable reluctance pickoff probes with an eddy current pickoff probe. Evaluation of mixing coefficients, β, for air-water flow in the THTF water mockup indicates that at the lowest mass flow rates, values of β were up to 10 times greater than the single-phase value, with the maximum occurring at the transition from bubbly to slug flow. At the highest flow rates the value of the two-phase mixing coefficient was only slightly greater than the single-phase value in the limited range for which data were obtained.

Thirty-one powered rod blowdowns have been conducted in the THTF through March 1979. The first of these tests was made with powers up to 122 kW/rod and outlet subcooling of 20 °F (11 °C) on all 49 rods. Subsequent tests have been made with inactive (zero-power) rods at different locations. Depressurization rates and core inlet and outlet mass flow rates are similar to the values predicted for a cold leg offset guillotine break obtained from SAR's for different vendor PWR's.

In general, RELAP predictions of the thermal-hydraulic behavior of the coolant during transients was quite good. RELAP predicted the appearance of pressurizer fluid at vertical outlet spool piece; made an excellent prediction of the depressurization curve; made a very good prediction of fluid density for the first 12 sec of the transient but missed later events because of limitations on handling energy fronts; and did a reasonably good job of predicting both volumetric and mass flows.

At a power of 122 kW/rod and an outlet subcooling of $\sim$ 22 °F ($\sim$ 12 °C), mean time to critical heat flux (CHF) was $\sim$ 0.7 sec with a range of 0.2 to 3.2 sec. Decreasing the rod power and increasing the outlet subcooling increased the time to CHF somewhat. Some preliminary calculations of the transient heat transfer coefficient have been completed. In one case, the steady-state value of the heat transfer coefficient, h, was $\sim$ 44,000 Btu/hr ft^2 °F; shortly after the occurrence of the CHF the value of h decreased to $\sim$ 400 Btu/hr ft^2 °F and remained there until $\sim$ 2 sec into the transient. From 2 until 12 sec into the transient the value of h was near $\sim$ 100 Btu/hr ft^2. For the remainder of the transient the value of h oscillated between 2 and 100 Btu/hr ft^2 °F.

(*h*) The following reports are available from NTIS, U.S. Dept. of Commerce, 5285 Port Royal Road, Springfield, Va. 22161.

Project Description, ORNL PWR Blowdown Heat Transfer Separate Effects Program–Thermal Hydraulic Test Facility (THTF), *ORNL/NUREG/TM-2*, Feb. 1976.

RELAP4/MOD5, A Computer Program for Transient Thermal Hydraulic Analysis of Nuclear Reactors and Related Systems Users Manual, *ANCR/NUREG/1335*, Sept. 1976.

PWR Blowdown Heat Transfer Separate-Effects Program Data Evaluation Report–Heat Transfer for THTF Series 100, W. G. Craddick, et al., *ORNL/NUREG-45*, Sept. 1978.

ORTCAL–A Code for THTF Heater Rod Thermocouple Calibration, L. J. Ott, R. A. Hedrick, *ORNL/NUREG-51*, Nov. 1978.

ORINC–A One-Dimensional Implicit Approach to the Inverse Heat Conduction Problem, L. J. Ott, R. A. Hedrick, *ORNL/NUREG-23*, Nov. 1977.

PWR Blowdown Heat Transfer Separate-Effects Program Data Evaluation Report–System Response for Thermal Hydraulic Test Facility Test Series 100, R. A. Hedrick, et al., *ORNL/NUREG-19*, Nov. 1977.

PWR Blowdown Heat Transfer Separate-Effects Progam Data Evaluation Report–THTF Test Series II, C. B. Mullins, et al. (to be published).

RLPSFLUX, RELAP with Surface Flux Modifications, S. B. Cliff, *ORNL/NUREG/CSD-5*, Sept. 1978.

COBRA III-I, An IBM-Compatible Version, D. M. Lister, et al., *ORNL/NUREG/CSD-9* (to be published).

PINSIM-MOD1: A Nuclear Fuel Pin/Electric Fuel Pin Simulator Transient Analysis Code, R. C. Hagar, R. A. Hedrick (to be published).

115-11262-720-52

CORE FLOW TEST LOOP (CFTL)

(*b*) Division of Reactor Research and Technology, U.S. Department of Energy. Work being carried out in cooperation with General Atomic Company, GCFR Program.

(*c*) Uri Gat, Program Manager. ORNL, 9102-2, P.O. Box Y, Oak Ridge, Tenn. 37830, (615-574-0559; FTS 624-0559).

(*d*) Experimental; applied analysis; performance evaluation; design conformation.

(*e*) The Core Flow Test Loop (CFTL) is a structural, thermal-flow helium loop to evaluate the performance of electrically simulated prototypes of fuel, control, and blanket elements of the Gas-Cooled Fast Reactor (GCFR). The loop will circulate helium at proposed GCFR operating temperatures (maximum gas temperature of 600 °C) and pressures (9 MPa). Test bundles will be representative of central segments of both fuel elements and control elements. The GCFR blanket bundle will be represented fully both in size and power generation. The single-ended (both electrical connectors on one end) electrically heated fuel rod simulators (frs) have a prototypical 20 percent cold worked stainless steel outer sheath (7.46 mm OD) artificially roughened over part of its length to represent the heat transfer enhancement required in the GCFR. The tribological effects at the roughened surface-grid spacer interface and the structural interaction between the frs and structural members will be evaluated. The blanket rod simulators (brs) are larger in diameter (12.8 mm) and are spiral wire wrapped for spacing. Steady state as well as normal shutdown, emergency shutdown, and depressurization sequences will be simulated in the loop. Temperatures and pressures data will be collected and evaluated. Structural evaluations will use x-radiography in conjunction with internal bundle markers during operation, and detailed post-test measurements. Results will be used in design modification and in the confirmation of design and of the computational methods used for bundle design and performance certification prior to construction of the GCFR demonstration facility.

(*f*) Scheduled beginning of operation, December 1981; prototype helium circulator undergoing tests, software for data acquisition system (DAS) under development.

(*h*) **System Design Description for the GCFR-Core Flow Test Loop,** A. G. Grindell, W. R. Huntley, *ORNL/GCR/F-77/26*, Dec. 13, 1977.

Quality Assurance Program Plan for the Core Flow Test Loop, W. R. Huntley, *Q-11590-ET-001-S-O*, Oct. 31, 1978.

Breakdown Voltage at the Electric Terminals of GCFR-CFTL Fuel Rod Simulators in Helium, Nitrogen, and Air, W. R. Huntley, T. B. Conley, to be issued as an ORNL-TM in third quarter FY 1979.

Thermal and Structural Analysis of the Pressure Boundary Flange for the Core Flow Test Loop, J. P. Sanders, J. C. Conklin, J. A. M. Boulet, K. W. Childs, *Paper No. 24, 4th Specialist Mtg. GCFR Heat Transfer*, Karlsruhe, FRG (Oct. 18-20, 1977).

Testing Plans of GCFR Core Elements in the CFTL, U. Gat, presented *NEA 4th Specialist Mtg. GCFR Heat Transfer*, Karlsruhe, Oct. 19-20, 1977.

Also see GCFR Program Annual Progress Reports, Oak Ridge National Laboratory.

115-11263-340-52

THERMAL-HYDRAULIC OUT-OF-REACTOR SAFETY (THORS) PROGRAM

(*b*) Division of Reactor Research and Technology, Department of Energy.

(*c*) Dr. M. H. Fontana, Manager, Breeder Reactor Safety Program, Oak Ridge National Laboratory, Oak Ridge, Tenn. 37830.

(*d*) Experimental and analytical investigation, applied research.

(*e*) Determine the thermal-hydraulic response of simulated sodium-cooled fast reactor subassemblies at normal and off-normal operating conditions, to determine the characteristics of sodium boiling in a reactor core at low-flow and/or natural-convection conditions, and to develop models to give a better understanding of sodium boiling. Experimental results are obtained using the Thermal-Hydraulic Out-of-Reactor Safety (THORS) Facility and the Sodium Boiling Test (SBT) Facility. These results are correlated and analyzed using standard codes (SAS, COBRA, SABRE), ORNL-developed codes (ORSLAP, LONAC, SIMBO), and other codes being developed in this task and elsewhere. The THORS Facility is an engineering-scale forced-convection sodium loop for thermal-hydraulic testing of simulated (electrically heated) reactor subassemblies at normal and off-normal operating condi-

tions. Flow capability is 600 gpm and power capability is 2 MW. The loop piping can withstand 1300 °F sodium continuously and 1650 °F intermittently. Transient power and flow automatic control systems, ample instrumentation, and a fast-response data acquisition system (DAS) allow investigation of simulated reactor transients culminating in sodium boiling and dryout at temperatures exceeding 1800 °F. Using 19-pin short and full-length bundles, the steady-state thermal-hydraulic effects of core-inlet blockages and heated-zone blockages have been determined. Transient and steady-state boiling tests (with and without blockages) have been conducted. Surface dryout has been attained at three conditions of flow and power. The SBT Facility is a single-channel sodium loop used to study free and low-flow forced convection dynamics of continuous sodium boiling. It consists of a vertical radiantly-heated tube simulating a single core subchannel, a large downcomer, upper and lower plena, and an electromagnetic pump. Profuse instrumentation, including an elaborate test-section void detection system (connected to the THORS Facility DAS), allows detailed determination of sodium voiding characteristics during transient and steady-state boiling. The Phase 1 test program to study steady-state free-convection boiling has been completed.

(*f*) A 19-pin full-length bundle has been installed in the THORS Facility and a comprehensive test program including steady-state single-phase thermal-hydraulic tests and transient boiling tests was begun in March 1979. Modifications are being planned for the SBT Facility in preparation for the Phase 2 test program.

(*g*) Early results showed that an inlet blockage covering 24 subchannels (about the size of a half-dollar) produced barely discernible temperature rises at nominal operating conditions. A six-channel central blockage well downstream in the heat generating region did not produce excessively high temperatures. Steady-state boiling induced downstream of the six-channel central blockage was stable and had no tendency to propagate axially or radially. Quasi steady-state boiling in an unblocked bundle at relatively low flows was more stable than was anticipated. This stability is thought to be due primarily to boiling incoherence caused by thermal inertia of the bundle housing.

(*h*) Publications 1/1/77-3/1/79 (ORNL/TM's can be obtained from the Department of Energy Technical Information Center, P.O. Box 62, Oak Ridge, Tenn. 37830.

Edge Blockages in 19-Pin Sodium-Cooled Bundles, J. T. Han, M. H. Fontana, P. A. Gnadt, J. L. Wantland, *Trans. Am. Nucl. Soc.* **26,** 335 (1977).

Blockages in LMFBR Fuel Assemblies, J. T. Han, M. H. Fontana, *Symp. Thermal and Hydraulic Aspects of Nuclear Reactor Safety* **2,** *Liquid Metal Fast Breeder Reactors*, ASME, 1977.

Dynamic Boiling Tests in a 19-Pin Simulated LMFBR Fuel Assembly, J. L. Wantland, N. E. Clapp, M. H. Fontana, P. A. Gnadt, N. Hanus, *Trans. Am. Nucl. Soc.* **27,** 567 (1977).

Maximum Wake Temperature and Nusselt Number Behind Blockages in Sodium-Cooled Bundles, J. T. Han, M. H. Fontana, J. L. Wantland, *Trans. Am. Nucl. Soc.* **27,** 564 (1977).

Calculated vs Experimental Temperature Distribution Behind a Six Channel Blockage, J. F. Dearing, *Trans. Am. Nucl. Soc.* **27,** 566 (1977).

A Model to Correlate Residence Time Measurements Behind Blockages, J. T. Han, *Trans. Am. Nucl. Soc.* **27,** 565 (1977).

SAS 3A Simulations for a 19-Pin Dryout Experiment, J. T. Han, E. T. Tomlinson, *Trans. Am. Nucl. Soc.* **28,** 438 (1978).

A Simple Transient Analysis of the THORS Bundle 6A Boiling Test Results, P. W. Garrison, *Trans. Am. Nucl. Soc.* **28,** 440 (1978).

Progress in Liquid-Metal Fast Breeder Reactor Safety Research and Development–An Overview of the Issues, M. H. Fontana, *Progress In Nuclear Energy* **3,** 199 (1978).

Radiation Heat Transfer in a 19-Pin Sodium Voided Bundle, M. Machbitz, B. Budiman, Y. Y. Roberts, S. M. Senkan (MIT), J. T. Han (ORNL), *Trans. Am. Nucl. Soc.* **30,** 416 (1978).

Maximum Sodium Temperature Correlation for Six-Channel FBR Subassembly Blockages, N. Hanus, J. T. Han, M. H. Fontana, J. L. Wantland, *Trans. Am. Nucl. Soc.* **30,** 417 (1978).

Temperature Distributions in 19-Rod Simulated LMFBR Fuel Assemblies During Operation to Sodium Boiling With and Without Inert Gas Injection (Out-of-Reactor Tests for ANL SLSF P1 Experiment)–Record of Experimental Data for Fuel Failure Mockup Bundle 5D, J. L. Wantland, M. H. Fontana, P. A. Gnadt, N. Hanus, R. E. McPherson, C. M. Smith, *ORNL/TM-5580*, Feb. 1977.

Temperature Distribution in the Duct Wall of 19-Rod Simulated Fuel Assemblies, D. G. Linz, J. L. Wantland. *ORNL/TM-5763*, Apr. 1977.

Effect of Duct Configuration on Peripheral Flow in 19-Rod Simulated LMFBR Fuel Assemblies, C. M. Smith, J. L. Wantland, *ORNL/TM-5827*, May 1977.

Fabrication of an Improved Tube-to-Pipe Header Heat Exchanger for the Fuel Failure Mockup (FFM) Facility, J. J. Prislinger, R. H. Jones, *ORNL/TM-5733*, May 1977.

ORSLAP–A Digital Computer Program for Dynamic Simulation of a Multinode Sodium Loop During Transients, R. A. Hedrick, J. S. White, *ORNL/TM-5322*, June 1977.

Local Sodium Boiling in a Partially Blocked Simulated Subassembly (THORS Bundle 3B), N. Hanus, P. A. Gnadt, M. H. Fontana, J. L. Wantland, *ORNL/TM-5862*, June 1977.

Dynamic Tests to Determine Heat Transfer and Flow in Simulated LMFBR Fuel Bundles, W. H. Sides, T. W. Kerlin, D. N. Dry, *ORNL/TM-4829*, Aug. 1977.

Blockages in LMFBR Fuel Assemblies–A Review of Experimental and Theoretical Studies, J. T. Han, *ORNL/TM-5839*, Sept. 1977.

State of the Art of Fuel Pin Simulators for LMFBR Out-of-Reactor Safety Tests–Status Report, W. E. Baucum, R. E. MacPherson, D. L. Clark, R. W. McCulloch, *ORNL/TM-5889*, Sept. 1977.

Steady-State Sodium Tests in a 19-Pin Full-Length Simulated LMFBR Fuel Assembly–Record of Steady-State Experimental Data for THORS Bundle 6A, J. L. Wantland, N. E. Clapp, M. H. Fontana, P. A. Gnadt, N. Hanus, R. H. Thornton, *ORNL/TM-6106*, Mar. 1978.

LONAC: A Computer Program to Investigate Systems Dynamics Under Conditions of Low Forced Flow and Natural Convection, R. J. Ribando, *ORNL/TM-6228*, Apr. 1978.

A Fluid Mechanics Model to Estimate the Leakage of Incompressible Fluids Through Labyrinth Seals, J. T. Han, *ORNL/TM-6373*, Aug. 1978.

SIMBO–A Simple Boiling Model of the Response of a Simulated Sodium-Cooled Breeder Reactor Subassembly to an Undercooling Transient, P. W. Garrison, *ORNL/TM-6343*, Sept. 1978.

Electron-Beam Welding of Fuel Pin Simulators to a Tubesheet, P. A. Gnadt, J. F. King, *ORNL/TM-6600*, Dec. 1978.

Sodium Boiling in a Full-Length 19-Pin Simulated Fuel Assembly (THORS Bundle 6A), R. J. Ribando, et al., *ORNL/TM-6553*, Jan. 1979.

Steady-State Sodium Tests in a 19-Pin Internally Guard-Heated Simulated LMFBR Fuel Assembly with a Six-Channel Internal Blockage–Record of Experimental Data for THORS Bundle 3C, N. Hanus, W. R. Nelson, et al., *ORNL/TM-6498*, Feb. 1979.

Grain Growth Control in Pt-8 Percent W by Powder-Metallurgy Processing, D. E. Harasyn, R. K. Williams, *ORNL/TM-6615*, Feb. 1979.

The Data Management System for the Thermal-Hydraulic Out-of-Reactor Safety Facility Computer-Controlled Data Acquisition System Configuration for Bundle 3C Operation, N. E. Clapp, *ORNL/TM-6745*, Feb. 1979.

115-11264-890-52

LOW-TEMPERATURE THERMAL ENERGY STORAGE (LTTES)–AQUIFER TECHNOLOGY DEVELOPMENT

(*b*) Department of Energy, Division of Energy Storage Systems.

(*c*) David M. Essenberg, Engineering Technology Division, Oak Ridge National Laboratory, P.O. Box Y, Oak Ridge, Tenn. 37830.

(*d*) Field; analytical; systems evaluation.

(*e*) Objectives of the Low-Temperature Thermal Energy Storage (LTTES) Program are (1) to develop sensible and latent heat storage technologies capable of effectively accepting, storing, and discharging thermal energy supplied at temperatures up to 250 °C, and (2) to define the potential of these technologies in the conservation of energy and natural resources. Of particular interest is the long-term (seasonal) storage of waste heat, solar thermal, utility cogenerated heat, and environmentally derived energies for application to building heating and cooling; aquifers storing hot or cold waters have been identified as a primary means for accomplishing these goals. Aquifers are subsurface geologic strata (principally gravel or sand layers) within which significant quantities of water exist and flow. Studies to explore the feasibility of aquifer storage include field studies to determine aquifer storage potential, to identify problems and develop solutions, and to validate predictive computer models, as well as computational support on charge-discharge strategies, numbers and locations of wells, aquifer fluid dynamics, and geochemistry. This is a national effort managed by ORNL with substantial university, government agency, and industrial participation.

(*f*) Active with management of demonstrations and supporting R&D being transferred to Battelle Pacific Northwest Laboratories.

(*g*) Field tests are being carried out with aquifers at two sites: one near Mobile, Ala., for hotwater storage; and the other at College Station, Tex., for the generation and storage of cold water. Initial injection difficulties in the hot water experiment were ascribed to plugging by fines transported in from the water source or deflocculation of the *in situ* clays; subsequent injection, storage, withdrawal cycles drawing water from a different source and operating with periodic backwashing gave more optimistic results. Interference tests have located several barrier boundaries and suggest transmissivities to be higher than previously estimated. Above 80 percent heat recovery is indicated from the second storage cycle. Injections in the first cycle of the cold water test proceeded at anticipated flow rates, though it was necessary to clean the input filters frequently. In the Texas temperature climate of winter 1978-79, it was not possible to chill significant quantities of water environmentally to temperatures below 9 °C.

(*h*) **Proceedings of 2nd Annual Thermal Energy Storage Contractors' Information Exchange Meeting,** *Oak Ridge Natl. Lab. Rept. CONF-770955: Program Overview*, H. W. Hoffman, Oak Ridge National Laboratory, p. 3;
Subsurface Waste Heat Storage, J. C. Warman, F. J. Moltz, Water Resources Research Institute, Auburn Univ., p. 24;
TES in Underground Aquifers, C. F. Tsang, Lawrence Berkeley Laboratory, p. 91;
Storage of Cold Water in Groundwater Aquifers, D. L. Reddell, Texas A&M Research Foundation, p. 152.
Proceedings of Thermal Energy Storage in Aquifers Workshop, *Lawrence Berkely Laboratory Rept., CONF-7805140*, Dec. 1978.

115-11265-130-55

ADVANCED TWO-PHASE INSTRUMENTATION PROGRAM

(*b*) U.S. Nuclear Regulatory Commission.

(*c*) K. G. Turnage, Principal Investigator, M.S. 7, Building 9204-1, P.O. Box Y, Oak Ridge, Tenn. 37830.

(*d*) Experimental and analytical applied research.

(*e*) Objective of the Advanced Two-Phase Instrumentation Program is the application of advanced instrument science to improve accuracy and precision of transient two-phase flow measurements required in reactor safety research. The program is pursuing two general tasks: hardware development and the application of instrument signal correlation and noise analysis to two-phase flow measurements. Hardware development includes the design, fabrication, testing and evaluation of improved instrumented spool pieces for transient, two-phase flow measurements in primary piping. Feasibility studies of novel instruments such as vortex shedding meters for application in two-phase flow measurements are being conducted. The noise analysis studies presently center on the application of advanced analysis techniques for determining velocity and void fraction of two-phase flows under conditions thought to be typical of a nuclear reactor reflood. Both local impedance probes and full-flow instruments are being used in these experiments.

(*g*) Testing of the first generation fluidic device from Harry Diamond Laboratories was completed. The device, although found to yield a meaningful relationship between voltage and momentum, was insufficiently compensated for temperature variations in the fluid. Testing of the Auburn meter in horizontal and vertical flow was completed. The device was found to agree well with gamma densitometer readings when no upstream obstructions existed. Two-phase flow testing of advanced spool piece 1 in air-water was completed. Data from horizontal, downflow and upflow mass flux measurements of acceptable accuracy in most flow regimes. Steady-state steam water experiments with full-flow drag targets and improved turbine monitor electronics are being performed to verify the mass flow model's accuracy. Local conductivity probes purchased from Atomic Energy of Canada, Ltd. (AECL) were tested in air-water two-phase flow. The probes were found to yield useful measurements of local velocity and void fraction. Air-water scoping tests with an enhanced vortex shedding flowmeter were completed. The probe's output signal appears to contain useful velocity information, particularly at very high and very low void fractions.

(*h*) **An Experimental Study of Flow Monitoring Instruments in Air-Water, Two-Phase Downflow,** J. D. Sheppard, et al., *Paper SNI-7-27, Proc. CREST Specialists Meeting on Trans. Two-Phase Flow,* (*CONF-760810*) Toronto, Canada (1976).
Quarterly Progress Report on Advanced Two-Phase Instrumentation Program for November-December 1976, J. D. Sheppard, et al., *ORNL/NUREG/TM-93*, (Mar. 1977).
Quarterly Progress Report on the Advanced Two-Phase Instrumentation Program for January-March 1977, J. D. Sheppard, et al., *ORNL/NUREG/TM-119*, (July 1977).
Advanced Two-Phase Instrumentation Program Quarterly Progress Report for April-June 1977, W. H. Leavell, et al., *ORNL/NUREG/TM-140*, (Dec. 1977).
Advanced Two-Phase Instrumentation Program Quarterly Progress Report for July-September 1977, P. A. Jallouk, et al., *ORNL/NUREG/TM-183*, (Apr. 1978).
Advanced Two-Phase Instrumentation Program Quarterly Progress Report for October-December 1977, P. A. Jallouk, J. E. Hardy, *ORNL/NUREG/TM-227*, (Sept. 1978).
Quarterly Progress Report on the Advanced Two-Phase Instrumentation Program for January-March 1978, K. G. Turnage, et al., *ORNL/NUREG/TM-250*, (Oct. 1978).
Quarterly Progress Report on the Advanced Two-Phase Instrumentation Program for April-June 1978, K. G. Turnage, et al., *ORNL/NUREG/TM-279*, (Jan. 1979).
(Quarterly progress reports may be obtained from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Va. 22161.)

115-11266-720-55

INSTRUMENT DEVELOPMENT LOOP

(*b*) U.S. Nuclear Regulatory Commission.
(*c*) D. G. Thomas, Program Manager, Oak Ridge National Laboratory, Building 9204-1, MS-7, Y-12 Plant, Oak Ridge, Tenn. 37830.
(*c*) Experimental applied research.
(*e*) The Instrument Development Loop (IDL) Program is part of the 2D/3D Refill and Reflood Experimental and Research Program. The objective of this program is the development and calibration of instruments for the Upper Plenum Test Facility (UPTF) core-upper plenum interface. Testing will be done in both air/water and steam/water loops. The air/water flow visualization loop will have a full-scale representation of a three-bundle vertical section of the UPTF while the steam/water loop will have a full-scale representation of a one-bundle vertical section of the UPTF.
(*f*) Initiated 10/1/78.
(*g*) Loops designed and under construction.

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OCEANIC HYDRODYNAMICS, INCORPORATED, 107 Meadowlark Drive, Salisbury, Md. 21801. Dr. Larry Bliven, Director of Physical Sciences.

116-11041-450-50

MEASUREMENT OF OCEANIC SURFACE FINE STRUCTURE

(*b*) NASA Wallops Flight Center.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) Laboratory investigations of oceanic surface phenomena are heing conducted at the NASA Wallops Flight Center wind-wave-current tank. Major new instrumentation consists of a dual axis laser anemometer which is capable of measuring wave induced turbulence. The primary objective of this project is to relate the wave induced eddy viscosity coefficient to the surface wave conditions. Wave induced turbulence is an important process in the redistribution of momentum and heat in the upper ocean. Thus this research is relevant to analyses of surface layer Ekman currents, thermocline erosion, and meterological phenomena.

116-11042-410-88

SEDIMENT TRANSPORT BY WAVES AND CURRENT

(*b*) Center for Marine Sciences, North Carolina State University.
(*d*) Experimental; basic and applied research.
(*e*) Sediment transport in lakes and the coastal zone is a function of wave as well as current conditions but most transport theories and data sets consider only currents as the transport mechanism. Therefore laboratory experiments of bed load sediment transport and the associated topographic features due to combined wave and current conditions were measured in the North Carolina State University hydraulics laboratory. Transport rates were measured by monitoring the motion of fluorescently dyed sediment and topographic features by a sonar probe. Spectra and probability density distributions of the ripples were computed. Capacitance wave height and hot film anemometer measurements quantified the flow field.
(*f*) Completed.
(*g*) Experimental data for bed load transport due to waves and currents support Bagnold's sediment transport theory which states that the immersed weight sediment transport rate is linearly related to the stream power available at the top of the bottom houndary layer. The proportionality constant is approximately 1.0 indicating that the work done by the fluid in the boundary layer is efficiently employed to transport sediment. Hino proposed that the constant of proportionality relating the power spectral density to the ripple number is a function of only the angle of repose for the equilibrium range of the spectra of fully developed bed forms. For local equilihrium conditions, however, the data demonstrate that the constant of proportionality is also a function of the flow field and the decay is more rapidly than the minus three power low.
(*h*) **Sediment Transport Phenomena Generated by a Combined Wave and Steady Flow Condition,** L. Bliven, *Ph.D. Thesis*, N. C. State Univ., Raleigh, N.C., 1977.
An Experimental Investigtion of Some Combined Flow Sediment Transport Phenomena, L. Bliven, N. E. Huang, G. S. Janowitz, *Report No. 77-3*, Center for Marine and Coastal Studies, N.C. State Univ., Raleigh, N.C., 1977.
Sediment Transport Phenomena Generated by Combined Wave and Steady Flow Conditions, L. Bliven, N. E. Huang, G. S. Janowitz, presented Fall Mtg. Amer. Geophysical Union, *Trans. Amer. Geophysical Union* **57,** 12, 1976.

116-11043-870-36

POLLUTION FROM RURAL RUNOFF

(*b*) Conducted by North Carolina State University with major funding hy EPA.
(*c*) Dr. F. J. Humenick, In Charge, Extension Department of Biological and Agricultural Engr., North Carolina State University, Raleigh, N.C. 27650, or Dr. Larry Bliven.
(*d*) Field experiment; basic and applied research.
(*e*) Investigation conducted hy interdisciplinary team of investigators representing four departments at NCSU. The purpose of this project was to investigate methods to quantifying areawide water quality from rural nonpoint sources. River basins often have a large number of rural nonpoint sources, i.e., subbasins, so complete spatial and temporal coverage of streams draining these sources is impractical. Fortunately, statistical theory provides valid techniques to estimate the mean and variance from randomly selected measurements. Either grab sampling or automated sampling can be employed in a statistical assessment. Field data obtained during a two-year period hy hoth sampling methods were employed to demonstrate the relative merit of the two sampling alternatives and numerous substudies were conducted to investigate particular topics of concern. Because each state is required hy law to evaluate the impact of rural nonpoint sources on water quality, the project results are pertinent to state water quality planning agencies. Two-day technology transfer workshops, which received national attention, were held in Raleigh, Atlanta, and Washington to instruct the scientific and technical community in the implementation of statistical methods to conduct area-wide water quality assessments and review the water quality data generated during this investigation of the Chowan River Basin. Nutrient loads and concentration timing are relevant to estuary and coastal zone biological modeling.
(*f*) Completed.
(*g*) The areawide annual water yield ohtained hy simple time stratified grab sampling was approximately equal to the historical average, but the precision of the site estimates was low because distributions of flow measurements at the sites were highly skewed. Therefore, the potential of daily rainfall predictions as a stratification method to provide increased precision at a given sampling frequency or hudget was demonstrated. Point-in-time comparisons of grab and automated sampling demonstrated that sampling techniques themselves impacted measured water quality concentrations. Dominant water quality variations among the forested and agricultural Piedmont plus poorly and well drained Coastal Plain areas were recorded hy both grab and automated sampling.
(*h*) **Monitoring Areawide Rural Water Quality,** L. Bliven, F. Humenik, F. Koehler, M. Overcash, *ASCE, J. Envir. Engr. Div.* **104,** EE6, 1978.
Rural Nonpoint Source Water Quality in a Southeastern Watershed, F. Humenik, L. Bliven, M. Overcash, F. Kodhler, *J. Water Pollution Control Federation*, in press.
Sampling Methods to Measure Nonpoint Source Impact on Water Quality, L. Bliven, F. Koehler, F. Humenik, M. Overcash, *ASAE Paper 77-4047*, Raleigh, N.C., June 1977.

Nutrient Yield Assessment by Different Sampling Strategies, M. Overcash, L. Bliven, F. Kodhler, J. Gilliam, F. Humenik, *Watershed Research in Eastern North America*, Chesapeake Bay Center for Environmental Studies, Smithsonian Inst., Edgewater, Md., 1:365-383, 1977.

An Analysis of Rural Nonpoint Source Water Quality, L. Bliven, F. Humenik, F. Koehler, M. Overcash, presented ASAE, Winter Meeting, Chicago, Ill., 1978.

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OHIO STATE UNIVERSITY, Agricultural Engineering Department, Ohio Agricultural Research and Development Center, 2073 Neil Ave., Columbus, Ohio 43210. G. L. Nelson, Chairman.

117-0165W-890-00

STABILIZATION OF STEEP LAND SLOPES

(*g*) Soil slippage measurements were continued on a bench terrace which first failed in March 1973. Little movement occurred in 1974, but additional slippage was observed in May 1975. In the next two years to May 1977 vertical movement in the slip area was less than 0.5 foot, but the failure rim moved an average of about 3.5 feet. These changes were much less than in the previous two years. Observations were continued on two pasture areas drained by 2-inch diameter corrugated plastic tubing installed in 1972. Although considerable flow took place, standing water was observed directly over the drains. Relative horzontal position of bench marks was unchanged and vertical movement was negligible during 1974-1977.

(*e*) For summary, see *Water Resources Research Catalog* **9**, 8.0363.

117-0382W-840-00

DRAINAGE SYSTEM DESIGN FOR POLLUTION CONTROL AND CROP PRODUCTION

(*g*) The tile drainage field experiment was in corn, soybeans, and oats (split plot) since 1976. Average corn yields in 1978 were 7589 kgs/ha for surface drainage only, 8781 kgs/ha for tile drainage only, and 9283 kgs/ha for combination of tile and surface drainage. These are more than 30 percent higher than the 10-year average, partly due to higher nitrogen fertilization. Soybean yields were 2688, 3226, and 3360 kgs/ha, respectively. They were nearly the same as the 3-year average. Oat yields were 2688, 3405, and 3620 kgs/ha, respectively. These were all more than 85 percent higher than the 4-year average. Average annual sediment losses for the 9-year period (1969-1977) were 2678 and 1676 kgs/ha for surface runoff and tile flow, respectively. Corresponding losses for NO_3-N for the same period were 16 and 25 kgs/ha; for P, 2.2 and 1.2 kgs/ha; and for K, 32 and 24 kgs/ha. Lysimeter plots were in corn in 1978 with yields varying from 8655 to 11,164 kgs/ha among the four soil types. Yields were nearly the same for the two water table levels.

(*h*) **Shallow Subsurface Drainage-Field Performance;** N. R. Fausey, R. D. Brehm, *Trans. Am. Soc. Agr. Eng.* **19**, 6, 1082-1084, 1976.

Age Effects on Surface and Subsurface Drain Flow, G. O. Schwab, *3rd Natl. Drainage Symp. Proc., ASAE*, pp. 10-13, 1977.

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OHIO STATE UNIVERSITY, Department of Agronomy, Columbus, Ohio 43210. Professor George S. Taylor.

118-10609-820-54

SIMULATING HEAT AND WATER FLOW DURING SOIL FREEZING AND THAWING

(*b*) National Science Foundation.

(*d*) Simulation; applied research.

(*e*) A numerical analysis study of simultaneous heat and water flow during freeze-thaw in soil. Flow cases are analyzed for various heat and water fluxes at the ground surface and for different initial water contents and temperature distributions. The simulation yields water and ice contents, temperature and water table elevations at various times. Frost heaving is simulated by expanding the soil matrix for large ice contents. The entire operation is programmed on an electronic computer. Fulfillment of the project objectives will yield information on the physical process of freezing and thawing and improve predictions of frost heaving for different soils.

(*g*) Evaluations have been made of water redistribution in soils during freeze-thaw and of water table recession during freezing. The agreement between simulated and experimental data has been demonstrated.

(*h*) **A Model for Coupled Heat and Moisture Transfer During Soil Freezing,** G. S. Taylor, J. N. Luthin, *Canadian Geotechnical Journal* **15**, 4, 548-555.

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OHIO STATE UNIVERSITY, Department of Chemical Engineering, Columbus, Ohio 43210. Jacques L. Zakin, Department Chairman.

119-07551-010-54

A VISUAL INVESTIGATION OF THE LAMINAR-TURBULENT TRANSITION

(*c*) Robert S. Brodkey.

(*d*) Experimental; basic; Doctoral theses.

(*e*) An experimental study into the basic mechanism of the entire laminar turbulent transition for both boundary layer and pipe flow, to elucidate clearly the steps that occur in the transition from laminar to turbulent flow and to clarify which, if any, theories apply for the various steps known to exist.

(*f*) Suspended until student assigned to project.

119-07552-020-54

TURBULENT MOTION AND MIXING

(*c*) Robert S. Brodkey.

(*d*) Experimental and theoretical; basic; Doctoral theses.

(*e*) An experimental and theoretical approach to the basic interactions of turbulence and the mixing of a scalar quantity such as mass. Mixing of heat or mass in a turbulent field can in principle be determined from a knowledge of the existing turbulence in the system and the molecular properties of the material being mixed. The object is to accomplish this prediction.

(*g*) A number of papers have been published by the investigators of this work. We have been able to accomplish the prediction for pipe flow in a mixing tank, and for a reactor configuration. Furthermore, we have been successful in extending the analysis to the prediction of the effect on chemical kinetics. Our current efforts involve modeling transfer at a solid boundary using the concepts of coherent structures.

(*h*) **Schliern Measurements of Fine Scale Mixing,** S. Zakanycz, *Kozprawy Inznierskie* **24**, 469, 1976.

Turbulent Motion, Mixing and Kinetics, *Proc. Levich Birthday Conf.*, p. 289, 1978.

119-07553-250-54

A VISUAL INVESTIGATION OF DRAG REDUCTION AND DRAG REDUCTION IN NONAQUEOUS SOAP SOLUTIONS

(*c*) Harry C. Hershey.

(*d*) Experimental; basic; Doctoral theses.

(*e*) Experimental study into the basic mechanism of drag reduction in pipe flow using high molecular weight polymer or soap solutions and into the laminar and turbulent behavior of soap solutions. Flow in the wall region of a drag reducing fluid is being compared visually to the flow of a pure solvent. The technique involves high speed

photography of colloidal-size particles. A parallel investigation is studying the laminar and turbulent behavior of various aluminum soaps in nonaqueous solvents.

119-08216-010-54

VISUAL INVESTIGATION OF THE TURBULENT BOUNDARY LAYER

(*c*) Robert S. Brodkey.
(*d*) Experimental; basic; Doctoral theses.
(*e*) An experimental study into the basic mechanism of boundary layer flow with emphasis on the interaction of the inner and outer regions. Stereoscopic viewing of the flow has been accomplished and currently simultaneous anemometry measurements by hot-film and laser methods are being investigated.
(*h*) **Mass Transfer at the Wall as a Result of Coherent Structures in a Turbulently Flowing Fluid,** K. N. McKelvey, H. C. Hershey, S. G. Nychas, *Intl. J. Heat and Mass Trans.* **21**, p. 593, 1978.
Pattern Recognized Structures in Bounded Turbulent Shear Flows, J. M. Wallace, H. Eckelmann, *J. Fluid Mech.* **83**, p. 673, 1977.
Vorticity and Turbulence Production in Pattern Recognized Turbulent Flow Structures, S. G. Nychas, J. M. Wallace, H. Eckelmann, *Phys. Fluids Sup.* **10**, 5225, 1977.
A Stereoscopic Visual Study of Coherent Structures in Turbulent Shear Flow, A. K. Praturi, *J. Fluid Mech.* **89**, p. 251, 1978.
Flow Visualization and Simultaneous Anemometry Studies of Turbulent Shear Flows, *Workshop on Coherent Structure of Turbulent Boundary Layers*, Lehigh Univ., Bethlehem, Pa., 1978.
Pattern Recognition, A Means for Detection of Coherent Structures in Bounded Turbulent Shear Flows, H. Eckelmann, J. M. Wallace, *Proc. Dynamic Flow Conf.*, p. 161, 1978.

119-09835-130-00

TURBULENT MOTION AND MIXING OF SOLIDS

(*c*) Robert S. Brodkey.
(*d*) Experimental and theoretical; basic; Doctoral theses.
(*e*) A cross-correlation technique has been developed to measure the turbulent statistics of solid particle motions in a turbulent field. A mixing tank was used to develop the complex flow field. Stereoscopic visualizations were used to aid in establishing the nature of the flow field.
(*g*) The cross-correlation technique can be used to establish the distribution of velocity vectors of solid particle motions in a complex three-dimensional flow field. Stereoscopic flow visualization can aid in understanding the nature of the flow field.

119-10075-370-54

TRANSPORT OF CRUDE OIL AS OIL-IN-WATER EMULSIONS

(*b*) NSF.
(*c*) Dr. J. L. Zakin.
(*d*) Experimental, applied research, M.S. thesis.
(*e*) The use of concentrated oil-in-water emulsions as a technique for transporting high viscosity and/or high pour point crudes is being compared with conventional heating techniques. Experimental results for turbulent flow of concentrated emulsions is being obtained and a feasibility study will be made.
(*g*) The variables of oil concentration, oil viscosity, pumping temperature and tube diameter, were investigated. Attempts to correlate turbulent pressure losses with the Dodge-Metzner correlation showed predicted pressure losses were generally high.
(*h*) **Reduction of Drag in the Turbulent Transport of Solid and Liquid Suspensions in Water,** J. L. Zakin, M. E. Borgmeyer, G. K. Patterson, presented *Intl. Symp. on Freight Pipelines*, Washington, 1976, to be published in Proceedings.
Transport of Crude Oil as Oil-In-Water Emulsions, J. L. Zakin, R. Pinaire, M. E. Borgmeyer, presented *ASME Fluids Engrg. Mtg.*, New Haven, 1977, *J. Fluids Engrg.* **101**, 100 (1979).
The Rheology of Oil-In-Water Emulsions, M. E. Borgmeyer, *M.S. Thesis*, Univ. Missouri-Rolla, 1975.
Pipeline Transport of Concentrated Oil-In-Water Emulsions, R. Pinaire, *M.S. Thesis*, Univ. of Missouri-Rolla, 1977.

119-11044-250-00

MECHANICAL DEGRADATION OF HIGH POLYMERS IN DILUTE SOLUTIONS

(*c*) Dr. Jacques L. Zakin.
(*d*) Experimental, basic research, M.S. thesis, Ph.D. thesis.
(*e*) The use of high polymers as drag reducing additives is limited by their tendency to break down under mechanical shear. In order to select the most resistant polymer systems to breakdown, the variables affecting mechanical degradation are being studied. These include molecular weight, molecular weight distribution, polymer type and structure, polymer-solvent interactions and level of shear.
(*g*) Increases in molecular weight gave increases in rate of degradation; increases in concentration gave decreases in rate of degradation in thermodynamically ""good" solvents but had little effect in "poor" solvents; rate of degradation was far greater and threshold molecular weight for degradation was dependent primarily on the shear sensitive high molecular weight species present.
(*h*) **Mechanical Degradation of High Molecular Weight Polymers in Dilute Solutions,** J. F. S. Yu, J. L. Zakin, G. K. Patterson, *J. Appl. Poly. Sci.*, in press.
Mechanical Degradation of Dilute Solutions of Polystyrene, J. L. Zakin, D. L. Hunston, *Drag Reduction: Proc. 2nd Intl. Conf. Drag Reduction*, p. 41, (BHRA Fluid Engineering, Bedford, England, 1977).
Effect of Solvent Nature on the Mechanical Degradation of High Polymer Solutions, *J. Appl. Polym. Sci.* **11**, 1763 (1978).
Mechanical Degradation in Dilute Polystyrene Solutions, D. L. Hunston, J. L. Zakin, *Polymer Sci. Eng.*, in press.
Mechanical Degradation of Polymers in Dilute Solutions, J. D. Culter, *Ph.D. Thesis*, Univ. of Missouri-Rolla, 1976.
A Study of Mechanical Degradation of High Molecular Weight Polymer in Dilute Solutions Under Controlled Hydrodynamic Shear, J. F. S. Yu, *Ph.D. Thesis*, Univ. of Missouri-Rolla, 1977.

119-11045-250-00

DRAG REDUCTION WITH POLYMER ADDITIVES

(*c*) Dr. Jacques L. Zakin.
(*d*) Experimental, basic research, M.S. thesis.
(*e*) The effects of polymer molecular structure, molecular weight distribution and polymer-solvent interactions on drag reduction.

OREGON STATE UNIVERSITY, School of Engineering, Corvallis, Oreg. 97331. W. L. Schroeder, Office of the Dean.

121-11046-340-52

A RESOURCE SURVEY OF LOW-HEAD HYDROELECTRIC POTENTIAL–PACIFIC NORTHWEST REGION

(*b*) U.S. energy Research and Development Administration.
(*c*) Peter C. Klingeman, Oregon Water Resources Research Institute, Oregon State University.
(*d*) Theoretical; applied research; for contractor and for thesis.
(*e*) Investigate the potential for low-head hydroelectric energy development for Oregon. To focus primarily on presently undeveloped sites but to include the possibility of adding

low-head turbines to water projects not normally associated with hydroelectric development (e.g., drops in large irrigation canals). Produce a document that will define for Oregon the potential for electrical energy production using low-head hydroelectric energy technology. For purposes of this research "low-head" will mean heads in the range of 3 m to 20 m and involve average annual energy potentials exceeding 200 kw (0.2 MW).

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PENNSYLVANIA STATE UNIVERSITY, College of Engineering, Department of Aerospace Engineering, University Park, Pa. 16802. Dr. Barnes W. McCormick, Department Head.

122-10043-550-50

FLOW PHENOMENA IN AXIAL FLOW INDUCERS

(*b*) National Aeronautics and Space Administration.
(*c*) Dr. B. Lakshminarayana.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) To gain sufficient knowledge and understanding of the flow in axial flow inducers to permit a systematic improvement in the flow, based on such knowledge and understanding. The flow measurements carried out so far include detailed hot-wire survey of the rotor passage resulting in quantitative knowledge of the three-dimensional mean velocity, as well as the turbulence flow field. In addition, solution of the flow field, based on viscous equations of motion in rotating coordinates, has been obtained.
(*g*) See Item (e).
(*h*) **On the Shear Pumping Effect in Rocket Pump Inducers,** B. Lakshminarayana, *Pumps–Analysis, Design and Application* **1,** Worthington Pump Inc., p. 4968, 1978.
An Experimental Study of Three Dimensional Boundary Layer and Turbulence Characteristics Inside a Rotating Channel, *J. Engineering for Power* **100,** 4, p. 676-690, 1978.

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PENNSYLVANIA STATE UNIVERSITY, College of Engineering, Department of Civil Engineering, Hydraulics Laboratory, University Park, Pa. 16802. Dr. Joseph R. Reed, Associate Professor.

123-08223-200-00

UNIFORM FLOW RESISTANCE IN OPEN CHANNELS

(*c*) Dr. J. R. Reed.
(*d*) Applied research; experimental; Master's thesis.
(*e*) The effect of shape on the Manning equation has been studied in a variably sloped plywood flume. A transition was used to connect rectangular and trapezoidal sections of the flume, and at any given time the two shapes had identical subcritical flows and slopes. Study was continued with the entire flume rectangular. A distant objective of this study is to attempt a correlation between resistance coefficients and turbulence measurements.
(*f*) Suspended.
(*g*) The Manning n values were significantly different for the rectangular and trapezoidal sections under the same flow conditions. In addition, the n values varied with flow in the rectangular section, but remained relatively constant in the trapezoidal section. Results with the entire flume rectangular show the n values dependent on slope as well as the Reynolds number.
(*h*) **Variability of Resistance Coefficients in Rectangular Channel Flow,** R. A. Etzel, *M.S. Thesis*, Penn. State Univ., May 1978.

123-08928-200-00

EVALUATION OF FRICTION SLOPE AVERAGING TECHNIQUES FOR VARIED CHANNEL FLOW

(*b*) U.S. Army graduate fellowship.
(*c*) Dr. J. R. Reed.
(*d*) Analytical; applied research; Master's thesis.
(*e*) The first phase of this study was aimed at evaluating seven different energy gradient averaging techniques which are now used in practice in step solutions of gradually varied flow profiles. One of the techniques tested was that used in HEC-2. Computer results of step computations in prismatic channels were compared against mathematically accurate solutions using numerical quadrature for increasingly shorter steps in a given channel reach. Both M and S profiles were analyzed. A second phase undertook development of 30 new friction slope models based on patterns observed in the original seven techniques.
(*g*) All seven techniques in the first phase showed a convergence to the true length as the number of steps increased from 1 to 50. However, each technique remained consistently separated from all the others in the quality of its estimate for a given profile throughout the range of steps. Each profile type studied had its own best friction slope model. Overall, two models fared well: one reported in a textbook by Vennard, and another used by the U.S.G.S. There was an indication that two of the formulas always were the upper and lower bounds of the estimates, and indeed some mathematical proof was possible. In the second phase, preliminary evaluation of the 30 new formulas showed promise that one or more might be better than the original seven.
(*h*) **New Manning Energy Gradient Models for Backwater Computations,** P. V. Anderson, *M. Engr. Paper*, Penn. State Univ., Mar. 1978.

123-10084-220-60

SEDIMENT FLOW PREDICTION AT HIGHWAY CONSTRUCTION SITES

(*b*) Pennsylvania Department of Transportation with the Federal Highway Administration.
(*c*) Dr. Arthur C. Miller, Assoc. Professor.
(*d*) Field investigation; developmental; Master's theses.
(*e*) Develop a method to predict sediment erosion from Pennsylvania highway construction sites which are instrumented by U.S.G.S.
(*g*) Final report of findings is being prepared for sponsor.
(*h*) **Rainfall Factors That Affect Erosion,** A. C. Miller, D. A. Daily, *Transportation Research Record*, 642, pp. 57-61, 1978.
Soil Properties That Affect Erosion, A. C. Miller, W. J. Veon, *Transportation Research Record*, 642, pp. 68-72, 1978.

123-10085-710-00

DETECTION OF SOIL MOISTURE LEVELS BY REMOTE SENSING

(*c*) Dr. David F. Kibler, Assoc. Professor, and Dr. Gert Aron.
(*d*) Experimental; applied research; Master's thesis.
(*e*) The feasibility of using multi-spectral scanner data to detect soil moisture changes on natural watersheds and spray irrigation plots is being studied.
(*f*) Suspended.
(*g*) Preliminary results show more promise for irrigated plots than for natural watersheds.

123-10086-300-60

MODEL STUDY OF LOYALSOCK CREEK

(*b*) Pensylvania Department of Transportation.
(*c*) Drs. Arthur C. Miller and Ronald A. Chadderton, Asst. Professors.
(*d*) Experimental; design; Master's thesis.
(*e*) A model of a meander immediately upstream from a state highway has been tested as an aid in the design of channel stabilization devices.
(*f*) Completed.
(*g*) Recommendations have been made recently to the sponsor.
(*h*) **Loyalsock Creek Study,** A. C. Miller, R. A. Chadderton, S. Brown, *Proc. 26th Ann. Hydraulics Div. Specialty Conf., ASCE*, Univ. of Maryland, Aug. 1978.

123-11051-810-05

RELATIONSHIPS AMONG VARIABLES IN THE SCS RUNOFF EQUATIONS

(*b*) U.S.D.A. graduate assistantship.
(*c*) Dr. Arthur C. Miller and Dr. W. J. Gburek of the USDA Northeast Watershed Research Center.
(*d*) Field investigation; developmental; Master's thesis.
(*e*) Investigate potential correlations between rainfall intensity distribution and curve number and between initial abstraction and potential maximum retention as they affect the SCS runoff equations.

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PENNSYLVANIA STATE UNIVERSITY, College of Engineering, Department of Mechanical Engineering, University Park, Pa. 16802. Dr. Donald R. Olson, Department Chairman.

124-08930-630-50

UNSTEADY BLADE PRESSURES

(*b*) NASA, Lewis Research Center, and Naval Sea Systems Command.
(*c*) Professor Robert E. Henderson.
(*d*) Experimental and theoretical; applied research, M.S. thesis.
(*e*) An instrumented blade is being developed to permit the measurement of unsteady pressure distribution on the rotor of an axial flow fan operated in a spatially varying inlet flow. A series of miniature pressure transducers are located along the blade chord to give the instantaneous pressure. The measurements will be compared with available unsteady cascade theories to demonstrate the effects of stagger angle, solidity and reduced frequency on the unsteady blade pressure distribution and lift.
(*f*) Completed.
(*g*) Results show major influence on unsteady stator pressure distributions to be the blade row solidity.
(*h*) **Investigation of the Unsteady Pressure Distribution on the Blades of an Axial Flow Fan,** R. E. Henderson, G. F. Franke, *Final Report*, Mar. 1978.
Unsteady Stator Response to Upstream Rotor Wakes, G. F. Franke, R. E. Henderson, *5th AIAA Aeroacoustic Conf., Paper No. 79-0579*, Mar. 1979.

124-08931-060-70

WALL PLUMES

(*b*) U.S. Department of Commerce, National Bureau of Standards, Center for Fire Research.
(*c*) Professor G. M. Faeth.
(*d*) Theoretical and experimental; M.S. and Ph.D. thesis research.
(*e*) The investigation considers the properties of laminar and turbulent thermal plumes along upright surfaces. Parameters of interest include mean velocity and temperature profiles, turbulence quantities, and heat transfer rates to the wall. Both combusting and noncombusting plumes are considered for two-dimensional flow conditions.
(*f*) Completed.
(*g*) Measurements of profiles of mean velocities, temperatures, and compositons as well as turbulence quantities were completed in both combusting and noncombusting plumes along vertical surface. Convective and radiative heat fluxes to the wall and radiative heat flux to the ambiance, as well as fuel burning rates, were also measured. Both laminar and turbulent flow were considered. These results were correlated by means of integral theories, as well as local similarity analysis, applied to turbulent flows.
(*h*) **Investigation of the Laminar Overfire Region Along Upright Surfaces,** T. Ahmad, G. M. Faeth, *J. Heat Transfer* **100**, pp. 112-119, Feb. 1978.
Laminar Combustion of Vertical Free-Standing Fuel Surfaces, E. G. Groff, G. M. Faeth, *Combustion and Flame* **32**, pp. 139-150, 1978.
Structure of a Turbulent Thermal Plume Rising Along an Isothermal Wall, T. Ahmad, E. G. Groff, G. M. Faeth, *J. Heat Transfer*, in press.
Turbulent Wall Fires, T. Ahmad, G. M. Faeth, *17th Symp. (Intl.) Combustion*, The Combustion Institute, Pittsburgh, in press.
Investigation of the Combustion Region of Fire-Induced Plumes Along Upright Surfaces, T. Ahmad, *Ph.D. Thesis*, Penn. State Univ., University Park, Pa., Aug. 1978.
Fire Induced Plume Along a Vertical Wall: Part I. The Turbulent Weakly Buoyant Region, T. Ahmad, E. G. Groff, G. M. Faeth; **Part III. The Turbulent combusting** Plume, T. Ahmad, G. M. Faeth, *Final Report, NBS Contract No. 5-9020*, Mar. 1978.

124-10020-290-50

SPRAY COMBUSTION

(*b*) National Aeronautics and Space Administration.
(*c*) Professor G. M. Faeth.
(*d*) Theoretical and experimental; M.S. and Ph.D. thesis research.
(*e*) The investigation considers the properties of liquid fuel combustion as a spray in a stagnant environment. Parameters of interest include profiles of mean quantities in both combusting and noncombusting sprays with axial symmetry.
(*g*) Profiles of mean velocity, temperature composition and drop size distribution as well as turbulent fluctuations and Reynolds stress have been measured in an evaporating spray. These results were compared with a theoretical model based on the locally homogeneous flow approximation and a second-order turbulence model. The results indicate that the locally homogeneous flow model provides a useful qualitative picture of the spray. However, models which allow for finite interphase transport rates are required for quantitative accuracy for most practical sprays.
(*h*) **Combustion of Liquid Sprays at High Pressures,** A. J. Shearer, G. M. Faeth, *NASA CR-135210*, Mar. 1977.
Evaluation of a Locally Homogeneous Model of Spray Evaporation and Combustion, A. J. Shearer, H. Tamura, and G. M. Faeth, *AIAA Paper No. 78-1042*, July 1978.
An Evaluation of a Locally Homogeneous Flow Model of Spray Evaporation, *Ph.D. Thesis*, Penn. State University, University Park, Pa., July 1979.

124-11052-190-45

PLUME IMPINGEMENT ON CEILINGS

(*b*) U.S. Department of Commerce, National Bureau of Standards, Center for Fire Research.
(*c*) Professor G. M. Faeth.
(*d*) Theoretical and experimental; Ph.D. thesis research.
(*e*) Investigation considers the impingement of turbulent plumes and fires on the underside of a horizontal ceiling. Stratified flow effects are considered as well.
(*g*) Convective heat transfer rates to the ceiling, and flame lengths along the ceiling were measured and correlated by means of integral models. Profiles of mean quantites have been measured in the flows.
(*h*) **An Investigation of Fire Impingement on a Horizontal Ceiling,** H-Z. You, G. M. Faeth, *Annual Report, NBS Contract No. 7-9020*, Oct. 1978.
Fire Impingement on a Ceiling, H-Z. You, G. M. Faeth, *1978 Tech. Mtg., Eastern Section of the Combustion Institute*, Miami, Fla., Nov. 1978.

124-11053-160-54

THE TRANSMISSION OF FLOW GENERATED NOISE THROUGH PIPE WALLS AT ACOUSTIC-PIPE COINCIDENCE

(*b*) National Science Foundation, Washington, D.C.
(*c*) Dr. Gerhard Reethof, Professor of Mechanical Engineering.

(*d*) Theoretical and experimental; applied research; M.S. and Ph.D. theses.
(*e*) At coincidence acoustic transmission loss of pipes with internal pressure fields drops by about 40 dB. Thus, noise from valves and other sources is readily transmitted through the pipe; a serious industrial noise problem. The dispersion relations for both the accoustic and the pipe wall vibratory modes were developed. Coincidence occurs when phase velocity of matched modes are equal.
(*g*) The theoretical and experimental results on the mechanisms of coincidence and the coincidence frequencies are in good agreement and ideas are being developed to reduce the effects of this phenomenon on the reduction in transmission loss.
(*h*) **Coincidence of Higher-Order Modes–A Mechanism of the Excitation of Cylindrical Shell Vibrations via Internal Sound,** J. L. Walter, *Ph.D. Thesis*, Penn. State Univ., July 1979.
Valve Noise Induced Pipe Vibrations Excited by Internal Higher-Order Acoustic Modes, J. L. Walter, *N.S. Report*, Penn. State Univ., June 1977.
The Transmission of Flow Generated Noise Through Pipe Walls–Experimental Verification, J. L. Walter, G. Reethof, *Proc. Noise-Con 1979 Conf.*, Purdue Univ., 1979.
The Coincidence of Higher-Order Acoustic Modes in Pipes with the Pipe Vibrational Modes, *Proc. 1978 Inter-Noise Conf.*, San Francisco, Calif., 1978.

124-11054-690-84

NON-CONDENSIBLE GASES IN REFRIGERANT CONDENSERS

(*b*) American Society of Heating Refrigerating and Air Conditioning Engineers.
(*c*) Professor Ralph L. Webb.
(*d*) Theoretical and experimental, applied research, Ph.D. thesis.
(*e*) This research will determine the effect of noncondensible gases for shell-side condensation in large refrigeration machines. Experiments are being conducted on a 250 ton water chiller. Noncondensible gases (CO_2) will be injected in the condenser and their effect on condenser performance will be measured. The distribution of noncondensible gases along the condenser length will also be determined by withdrawing gas samples. A numerical calculation model is also being developed to predict the effect of non-condensible gases. The theoretical predictions will be compared with the test data to permit generalization of the experimental results.
(*f*) In progress. Experiments to begin Summer 1979. Computer program partially completed.

124-11055-190-54

EXTENDED SURFACE FOR AGUMENTATION OF FILM CONDENSATION

(*b*) National Science Foundation.
(*c*) Professor Ralph L. Webb.
(*d*) Experimental and theoretical; applied research, M.S. and Ph.D. theses.
(*e*) A new surface geometery is being developed for condensation on horizontal tubes. The surface geometry consists of an array of square spine fins. A simplified analytical model has been developed which predicts 50 percent savings of fin material, relative to presently used commercial surfaces. The surface geometry will be applied to a horizontal tube yielding experimental data. Further work will be performed in a refined analytical model and additional data taken with different fluids.
(*f*) In progress. Theoretical predictions complete.

124-11056-210-00

HELICAL RIB ROUGHNESS

(*c*) Professor Ralph L. Webb.
(*d*) Experimental, M.S. thesis research.
(*e*) The investigation considers the heat transfer and pressure drop characteristics of flow through the inside of tubes roughened by a helical, repeated-rib, two-dimensional geometry. The effect of rib helix angle will be determined and an optimum helix angle will be defined.
(*f*) Measurements for three different helix angles, 70°, 49°, 30° respectively. Correlations of the friction and heat transfer data are being derived and an optimum performance helix angle has been defined.

124-11057-210-52

INTERNALLY FINNNED TUBES

(*b*) Department of Energy.
(*c*) Professor Ralph L. Webb.
(*d*) Experimental and theoretical, M.S. thesis research.
(*e*) The investigation is a study of friction and heat transfer correlations on internally finned tubes. A variety of fin heights and spacings will be tested to determine the effects of geometry of the geometrical parameters. Developed correlations will be compared to existing correlations in an attempt to improve the state-of-the-art.
(*f*) In progress.

124-11058-140-52

OFFSET STRIP FINS

(*b*) Department of Energy, Division of Engineering, Mathematical and Geo-Sciences.
(*c*) Professor Ralph L. Webb.
(*d*) Experimental and theoretical, M.S. and Ph.D. thesis research.
(*e*) The offset strip fin is a high performance surface geometry used in compact heat exchangers. Presently, an understanding does not exist to allow prediction of its heat transfer and friction characteristics as a function of its geometric parameters. This work will seek to develop a generalized understanding of the friction characteristics of this basic fin type. The experimental portion of the program will be performed with a 10:1 scale up in a water tunnel.
(*f*) Work to be initiated September 1, 1979.

124-11059-870-36

SIMPLIFIED STACK SAMPLING SYSTEM

(*b*) EPA, Environmental Science Research Laboratory.
(*c*) Professor Robert Jennings Heinsohn.
(*d*) Experimental and theoretical, applied research and design, M.S. thesis.
(*e*) A simplified stack sampling system is being designed which will simultaneously withdraw and dilute a sample of a process gas with dry atmospheric air. After the sample gas stream has been cooled and diluted, the small particles are captured for analysis. The particles are believed to be representative of those that a plume ultimately adds to the atmosphere.
(*h*) **A Comparison of the Particulate Matter Obtained Using a Dilution Sampling System and a Method 5 Sampling System,** R. J. Heinsohn, G. J. Wehrman, J. S. Davis, G. W. Anderson, *Paper No. 77-12.1*, *Proc. Ann. Mtg. Air Pollution Control Assoc.*, (1977).

PENNSYLVANIA STATE UNIVERSITY, Institute for Science and Engineering, Applied Research Laboratory, P.O. Box 30, State College, Pa. 16801. J. C. Johnson, Laboratory Director.

125-03807-230-50

THERMODYNAMIC EFFECTS ON CAVITATION

(*b*) National Aeronautics and Space Administration.
(*c*) Dr. J. Will and Dr. Michael L. Billet.
(*d*) Experimental and theoretical.

(*e*) Investigations are carried out in the high speed cavitation tunnel employing various working fluids. At the present time, the primary fluid is Freon 113. Thermodynamic effects are investigated for both developed and limited cavitation over a range of temperatures and velocities. Analytical investigations are also being conducted.
(*f*) Completed.
(*g*) The experimental data for developed cavitation obtained in this investigation and by other investigations was correlated in terms of an entrainment theory.
(*h*) **Correlations of Thermodynamic Effects for Developed Cavitation,** M. L. Billet, J. W. Holl, D. S. Weir, *Proc. Symp. Polyphase Flow in Turbomachinery, ASME*, pp. 271-289, Dec. 1978.

125-08235-230-21

THE SCALING OF TRAILING VORTEX CAVITATION

(*b*) David W. Taylor Naval Ship Research and Development Center, Naval Sea Systems Command.
(*c*) Dr. M. L. Billet and Dr. J. W. Holl.
(*d*) Experimental and theoretical; basic research.
(*e*) Study various forms of limited cavitation in vortex flows, i.e., vaporous and non-vaporous cavitation; determine the factors which control the $C_{p_{min}}$ of the vortex and its scaling.
(*h*) **Secondary Flow Generated Vortex Cavitation,** M. L. Billet, *Proc. 12th Symp. Naval Hydrodynamics* **V**, 1978.
An Approximate Method for the Solution of the Direct Problems of an Open Rotor, M. L. Billet, Applied Research Laboratory, *Report No. 78-161*, May 1978.
Secondary Flow Vorticity in the Passage of a Rotor, M. L. Billet, Applied Research Laboratory, *Report No. 77-243*, Aug. 1977.
Cavitation Results for a Secondary Flow Generated Trailing Vortex, M. L. Billet, *Report No. 76-234*, Aug. 1976.
Flow Measurements Behind a Rotor Operating in a Boundary Layer, M. L. Billet, *Report No. 76-260*, Oct. 1976.

125-08236-230-22

THE EFFECT OF POLYMER ADDITIVES ON CAVITATION

(*b*) Naval Sea Systems Command.
(*c*) Dr. J. William Holl and Dr. Michael L. Billet.
(*d*) Experimental and theoretical.
(*e*) Determine the effect of polymer additives on cavitation in a shear flow and on streamlined bodies.
(*f*) Completed.
(*h*) **Influence of Gas Content and Polyethylene Oxide Additive Upon Confined Jet Cavitation in Water,** C. B. Baker, J. W. Holl, R. E. A. Arndt, *Proc. ASME Cavitation and Polyphase Flow Forum*, 1976.
A Note of the Inhibition of Cavitation in Dilute Polymer Solution, R. E. A. Arndt, M. L. Billet, J. W. Holl, C. B. Baker, *Proc. ASME Cavitation and Polyphase Flow Forum*, 1976.

125-08916-230-22

SCALING LAWS FOR CAVITATION DAMAGE

(*b*) Applied Research Laboratory E&F Program, Naval Sea Systems Command.
(*c*) Dr. J. William Holl and Mr. David R. Stinebring.
(*d*) Experimental and theoretical.
(*e*) Problem concerns the determination of scaling laws for cavitation damage in a flow system. Initial tests are concerned with effect of velocity on cavitation damage on ogive nosed bodies.
(*h*) **Two Aspects of Cavitation Damage in the Incubation Zone: Scaling by Energy Considerations and Leading Edge Damage,** D. R. Stinebring, J. W. Holl, R. E. A. Arndt, *Joint Symposium on Design and Operation of Fluid Machinery* **II**, Fort Collins, Colo., June 1978.

125-08917-630-20

INVESTIGATION OF UNSTEADY FORCES AND MOMENTS ON AN AXIAL FLOW FAN ROTOR BLADE

(*b*) Office of Naval Research (Project SQUID), Naval Sea Systems Command.
(*c*) Mr. Edgar P. Bruce.
(*d*) Experimental and theoretical; basic research; Ph.D. thesis.
(*e*) Measure and analyze the unsteady normal force and pitching moment on the mid-span segment of a blade of an axial flow fan rotor operating in a flow whose axial velocity component varies sinusoidally in the circumferential direction. The program variables are blade camber, reduced frequency, blade space-to-chord ratio, blade stagger angle, and blade mean angle of attack. Theoretically, extend Henderson's unsteady cascade lift analysis to include the unsteady pitching moment. The experimental results will be used to provide design information and to assess the validity of available theoretical models.
(*g*) Test results are being reduced and analyzed at reduced frequencies from 0.2 to 5.0. Theoretical model development is nearing completion.
(*h*) **Design and Evaluation of Screens to Produce Multi-Cycle Sinusoidal Velocity Profile,** E. P. Bruce, *AIAA Paper 74-623*, July 1974.
The ARL Axial Flow Research Fan, E. P. Bruce, *ASME Paper 74-FE-27*, May 1974.
Axial Flow Rotor Unsteady Response to Circumferential Inflow Distortions, E. P. Bruce, R. E. Henderson, *Project SQUID Tech. Rept. PSU-13-P*, Sept. 1975.

125-08920-160-21

RADIATED SOUND DUE TO ROTOR OPERATING IN A TURBULENT INFLOW

(*b*) David W. Taylor Naval Ship Research and Development Center.
(*c*) Dr. B. Lakshminarayana and Dr. Donald E. Thompson.
(*d*) Experimental and theoretical; applied research; M.S. thesis.
(*e*) Measurements of turbomachinery rotor radiated sound spectra were correlated with aerodynamic measurements of the inlet turbulence, guidevane wake and secondary flow strengths for various guidevane configurations. Inlet turbulence data indicates that the major effect of flow contraction appears to be the elongation of turbulent eddies. These eddies then dominate the blade passing frequencies. Decreasing eddy size by use of a grid revealed secondary flow strength to be the second major noise source.
(*f*) Final reporting stage.
(*h*) **Noise Due to Interaction of Boundary Layer Turbulence with a Compressor or a Propulsor Rotor,** N. Moiseev, B. Lakshminarayana, D. E. Thompson, *AIAA J. Airc.* **15**, 1, 1978.

125-08923-550-22

RESEARCH AND DEVELOPMENT OF PROPULSORS FOR SUBMERGED VEHICLES AND HIGH SPEED SURFACE SHIPS

(*b*) Naval Sea Systems Command.
(*c*) Dr. R. E. Henderson and Mr. W. S. Gearhart.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) A continuing program is being conducted to develop propulsors having specific performance goals with respect to noise, cavitation, weight and efficiency. Single and counterrotating propellers, ducted propellers, pumpjets, and waterjet propulsion devices are considered. Propulsor design, fabrication and experimental evaluations are conducted to determine the steady state propulsive and cavitation performance. Theoretical studies included propulsor trade-off evaluations, blade design and axisymmetric flow field predictions.
(*h*) **Computer-Assisted Design of Pump Impellers,** M. C. Brophy, *M.S. Report*, Penn. State Univ., Mar. 1978.

Performance of Ducted Propellers Fitted to Surface Craft, W. S. Gearhart, R. E. Henderson, *Proc. 18th Amer. Towing Tank Conf.* **I,** Aug. 1977.

125-08924-550-22

ROTOR RESPONSE TO INLET DISTORTIONS

(*b*) NASA, Lewis Research Center; Naval Sea Systems Command.
(*c*) Dr. R. E. Henderson.
(*d*) Experimental and theoretical; basic research; M.S. thesis.
(*e*) The unsteady response of an axial-flow rotor to various inlet velocity distortions is studied by the investigation of the flow at the inlet and exit of the blades. The influences of rotor geometry–solidity, stagger angle, camber–are investigated. Detailed surveys of the flow field are conducted and the results compared with theoretical predictions.
(*f*) Completed.
(*g*) Results show that blade row solidity, stagger angle and intra-blade phase angle have predominant effect on distortion attenuation.
(*h*) **The Response of Turbomachine Blades to Low Frequency Inlet Distortions,** J. H. Horlock, E. M. Greitzer, R. E. Henderson, *ASME Trans., J. Engrg. Power* **99,** 2, Apr. 1977.
The Effects of Design and Operating Variables on the Response of an Axial Flow Fan to Inlet Flow Distortions, A. M. Yocum, *M.S. Thesis, Penn. State Univ., Aug. 1978.*
The Unsteady Response of an Axial Flow Turbomachinery Rotor to Inlet Flow Distortions, L. C. Barr, *M.S. Thesis,* Penn. State Univ., Mar. 1979.
The Effects of Some Design Parameters of an Isolated Rotor on Inlet Flow Distortions, A. M. Yocum, R. E. Henderson, *ASME Paper 79-GT-93,* 1979.
The Unsteady Design of Axial-Flow Turbomachines, R. E. Henderson, *ASCE-IAHR/AIHR-ASME Symposium on Fluid Machinery* **II,** June 1978.

125-08926-030-22

MEASUREMENT OF FORCES ON MODELS IN A WATER TUNNEL

(*b*) Naval Sea Systems Command.
(*c*) Mr. W. R. Hall, and Mr. Fred E. Smith.
(*d*) Experimental; some basic and applied aspects.
(*e*) The prediction of the powering performance, i.e., speed and power requirements for submerged vehicles from water tunnel tests has always suffered from the need to make tunnel interference corrections and a large Reynolds number extrapolation. Currently, testing techniques to obtain powering predictions from water tunnel tests have been developed and compared with tow tank tests and prototype tests. Agreement between sources has been satisfactory.

125-08927-030-22

TUNNEL WALL INTERFERENCE FOR BODIES OF REVOLUTION

(*b*) Naval Sea Systems Command.
(*c*) Mr. William R. Hall and Mr. Fred E. Smith.
(*d*) Experimental and theoretical.
(*e*) Body forces measured with large model-to-tunnel diameter ratio bodies require substantial corrections to predict vehicle performance under free-field condition. This investigation is intended to develop better corrections for various model configurations.
(*g*) New test programs using various body shapes have been developed. Hardware design in progress.
(*h*) **Horizontal Buoyancy Effects on the Pressure Distribution of an Axisymmetric Body Operating in a Cylindrical Duct,** G. C. Lauchle, *ARL TM, File No. 78-170,* June 1978.

125-10045-630-31

RESEARCH INTO PREVENTION OF DRAFT-TUBE SURGING IN HYDRAULIC TURBINES AND PUMP-TURBINES

(*b*) Bureau of Reclamation, Denver, Colo.
(*c*) Walter S. Gearhart.
(*d*) Experimental and applied research.
(*e*) Evaluate a technique intended to prevent the occurrence of draft tube swirl in hydroelastic turbines and pump-turbines. The results of this program will be used to determine the feasibility of applying this method in preventing draft tube surging and to what range and type of turbomachine it is most applicable.
(*h*) **Analysis of the Flow Through Turbine Wicket Gates with an Application to the Prediction of Draft Tube Surge,** A. M. Yocum, *Proc. Joint Symp. Design and Operation of Fluid Machinery* **I,** Fort Collins, Colo., 1978.
Studies of a Method to Prevent Draft Tube Surge in Pump-Turbines, T. Seybert, W. S. Gearhart, H. T. Falvey, *ASCE-IAHR/AIHR-ASME Joint Somposium* **I,** Fort collins, Colo., 1978.

125-10047-230-22

APPLICATION OF LDA SYSTEM TO MEASURE CAVITATION NUCLEI

(*b*) Naval Sea Systems Command.
(*c*) Dr. M. L. Billet.
(*d*) Experimental.
(*e*) A method has been developed to measure the size and distribution of possible cavitation nuclei and is currently being used in several water tunnels.

125-11048-230-22

CAVITATION AND CAVITATION NOISE SCALING

(*b*) Naval Sea Systems Command.
(*c*) Dr. M. L. Billet and Dr. D. E. Thompson.
(*d*) Experimental and theoretical; basic research.
(*e*) Study of various types of cavitation that occur of hydrofoil and the resulting radiated noise.
(*h*) **Initial Investigation of Stationary Hydrofoil Cavitation and Cavitation Noise Scaling,** M. L. Billet, D. E. Thompson, Applied Research Laboratory, *Report No. 77-327,* Dec. 1977.
Blade Surface Cavitation Noise, M. L. Billet, D. E. Thompson, *Proc. Joint Symp. Design and Operation of Fluid Machinery* **II,** pp. 523-542, 1978.

125-11049-030-22

HYDRODYNAMIC DESIGN OF SUBMERGED BODIES

(*b*) Naval Sea Systems Command.
(*c*) Dr. G. H. Hoffman.
(*d*) Theoretical, applied research.
(*e*) Advanced numerical methods are being developed for the prediction of flow fields about submerged vehicles, including the effects of a propulsive device. Studies are also being made of drag minimization and turbulence model improvement.
(*h*) **A Method for Calculating the Flowfield in the Tail Region of a Body of Revolution,** G. H. Hoffman, *ARL TM 78-211,* July 1978.
A Simplified Method for Predicting Body Temperature Distribution in the Preliminary Design of Heated Underwater Bodies, J. J. Eisenhuth, G. H. Hoffman, *ARL TM 79-02,* Jan. 1979.
The Laminar Velocity Profile in a Flat Plate Boundary Layer with Surface Roughness, G. H. Hoffman, J. L. Lumley, *ARL TM 77-150,* May 1977.
Horizontal Bouyancy effects on the Pressure Distribution of a Body in a Duct, G. C. Lauchle, *AIAA J. Hydronautics,* Apr. 1979.

125-11050-160-22

FLOW NOISE IN A TRANSITION REGION

(*b*) Naval Sea Systems Command.
(*c*) Dr. G. C. Lauchle.
(*d*) Theoretical and experimental, basic research.

(*e*) The acoustic characteristics of the laminar to turbulent transition region are being investigated on a fundamental level to develop a theory for the resulting self- and radiated noise.

(*h*) **On the Radiated Noise Due to Boundary-Layer Transition,** G. C. Lauchle, *ARL TM 78-204*, July 1978.
Acoustic Efficiency of Boundary-Layer Transition, G. C. Lauchle, *ARL TM 78-285*, Nov. 1978.

UNIVERSITY OF PITTSBURGH, School of Engineering, Department of Chemical and Petroleum Engineering, Pittsburgh, Pa. 15261. Dr. George E. Klinzing, Associate Professor and Graduate Coordinator.

126-11047-260-54

ELECTROSTATICS IN PNEUMATIC TRANSPORT

(*b*) NSF.
(*d*) Experimental, applied.
(*e*) Investigate the fundamentals of charge transfer between the particles and the tube wall. This charge is measured and related to the parameters of the solids and fluid flowing.

UNIVERSITY OF PITTSBURGH, Department of Civil Engineering, Water Resources Program, Pittsburgh, Pa. 15261. Professor Chao-Lin Chiu, Program Chairman.

127-08935-300-54

SECONDARY CURRENTS IN NATURAL STREAMS AND RIVERS

(*b*) National Science Foundation.
(*d*) Analytical, with field data.
(*e*) Develop a technique and procedure for computing secondary currents in natural streams and rivers, and use the technique to study the characteristics, development, and sensitivity of secondary currents to various factors affecting them.
(*f*) Completed.
(*g*) A technique for computing secondary currents has been developed with which the three-dimensional structure of flow in streams and rivers can be computed, simulated, and analyzed. Such a result enables investigating many other transport processes in streams and rivers which are inherently three-dimensional.
(*h*) **Three-Dimensional Open Channel Flow,** C.-L. Chiu, D. E. Hsiung, H. C. Lin, *J. Hydraulics Div., ASCE* **104**, HY8, Aug. 1978.

127-09845-200-00

APPLICATIONS OF KALMAN FILTERING THEORY IN ESTIMATION OF HYDRAULIC PROCESSES

(*d*) Analytical, experimental.
(*e*) Modern estimation theory using Kalman filters is being tested for its effectiveness in estimation of parameters and variables of hydraulic systems, such as the open channel flow, stream temperature fluctuation, and sediment transport, etc.
(*g*) Kalman filter has been applied to estimating Manning's resistance coefficient and flow profiles in open channels, and stream temperature.
(*h*) **Kalman Filter in Open Channel Flow Estimation,** C.-L. Chiu, E. Isu, *J. Hydraulics Div., ASCE* **104**, HY8, Aug. 1978.
Stream Temperature Estimation Using Kalman Filter, C.-L. Chiu, E. Isu, *J. Hydraulics Div., ASCE* **104**, HY9, 1978.
Applications of Kalman Filter to Hydrology, Hydraulics and Water Resources, a book edited by Chao-Lin Chiu, published by Stochastic Hydraulics Program, Dept. of Civil Engrg., Univ. of Pittsburgh, Pittsburgh, Pa. 15261.

127-11060-200-54

ROLES AND EFFECTS OF SECONDARY CURRENTS IN OPEN CHANNELS

(*b*) National Science Foundation.
(*c*) Dr. Chao-Lin Chiu, Professor of Civil Engineering.
(*d*) Analytical, with field and laboratory data.
(*e*) Investigate the role and effect of secondary currents on the sediment concentration at various points and regions within transverse cross sections of open channel flow and on the cross sectional average of sediment concentration.
(*g*) Secondary currents in a triangular, rectangular, and alluvial channel have been completed which show significantly different patterns. These results will be included in the next phase of the project to compute sediment concentration.
(*h*) **Secondary Currents Under Turbulence in Open Channels of Various Geometrical Shapes,** C.-L. Chiu, D. E. Hsiung, R. C. H. Lin, *Proc. XVIII Cong. Intl. Assoc. Hydraulic Research*, Cagliari, Italy, Sept. 10-15, 1979.

POLYTECHNIC INSTITUTE OF NEW YORK (see New York, Polytechnic Institute of listing).

PORTLAND STATE UNIVERSITY, Department of Engineering, Portland, Oreg. 97207. Professor H. Erzurumlu, Head.

128-11710-430-20

DYNAMIC RESPONSE OF CABLE SYSTEMS WITH CHANGING LENGTHS

(*b*) Office of Naval Research, Ocean Technology Division.
(*c*) Dr. Herman Migliore, Asst. Professor, Mechanical Engineering.
(*d*) Theoretical, experimental; applied and basic research.
(*e*) Investigation of the dynamic behavior of cable systems which change length in time, as in the payout/reel-in case. Equations of motion are solved in a continuous fashion using numerical techniques, Method of Weighted Residual. Analytic results are based on experimentally determined material and hydrodynamic properties and are compared to laboratory-sized test results.
(*g*) Material damping has been incorporated in analytic model. Comparison of analytic results to laboratory data shows good agreement for the case of low-stiffness cable. Progress is being made on developing an optimized solution procedure and increasing the versatility of the solution to other cables and cable configurations.
(*h*) **Dynamic Treatment of Cable Systems Which Change Length With Time,** H. Migliore, H. Zwibel, *Proc. 6th Canadian Congress of Applied Mechanics*, pp. 383-384, May 1977.
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PURDUE UNIVERSITY, Department of Agricultural Engineering, West Lafayette, Ind. 47907. Dr. G. W. Isaacs, Department Head.

129-03808-830-05

PREDICTING RUNOFF AND GROSS EROSION FROM FARMLAND AND DISTURBED AREAS

(*b*) USDA, Science and Education Administration, Agricultural Research; Agricultural Experiment Station, Purdue University.
(*c*) Dr. G. R. Foster.

(*d*) Experimental investigation; basic and applied research.
(*e*) The relationships of rainfall, soil, topographic, land-use, and management parameters to runoff and soil erosion are evaluated from field-plot and laboratory data, and the mechanics of soil erosion by water are studied as a basis for mathematically simulating the soil erosion process.
(*g*) The effect of concave slopes and strips of grass and crop residue on deposition of soil aggregates and primary particles by overland flow was studied on field plots under simulated rainfall. The influence of a nonerodible layer on rill erosion rates and eroded rill width was described by a theoetically based model which was validated with field data. A comprehensive model for nonpoint source pollution analyses was developed to evaluate the influence of soil, management practices, topography and structures on the amount and composition sediment leaving farm fields. A new guideline manual, Agricultural Handbook 537, for the Universal Soil Loss Equation was published.
(*h*) **An Erosion Equation Derived from Basic Erosion Principles,** G. R. Foster, L. D. Meyer, C. A. Onstad, *Trans. Amer. Soc. Agric. Engrs.* **20,** 4, pp. 678-682, 1977.
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Deposition of Non-Uniform Sediment by Overland Flow on Concave Slopes, S. S. Davis, M.S. Thesis, Purdue Univ., 1978.
Predicting Rainfall Erosion Losses, W. H. Wischmeier, D. D. Smith, *Science and Education Administration, USDA, Agriculture Handbook 537,* 58 p., 1978.
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129-07584-820-61

IMPROVING THE QUALITY OF LAND AND WATER RESOURCES

(*c*) Dr. E. J. Monke.
(*d*) Experimental, theoretical, field investigation, applied research.
(*e*) Study the effect of drainage practices on cropping management, crop response, and water, sediment and nutrient yields; to investigate factors affecting soil erosion and crusting; to measure and predict sediment and related chemical pollution from agricultural lands; and to study the dynamics of water and pollutant movement in soil.
(*g*) Collection and analysis of runoff, sediment yield and nutrient loss data from a 4900 ha agricultural watershed have been continued. A computer model was developed to identify source areas of the sediment and related chemical pollutants based on the output data, soils and topographic information, and land use. Several smaller, single practice watersheds have been instrument within the large watershed to verify the model results and to provide baseline information for effects of land use in runoff water quality. Battery powered sampling instrumentation was also developed and tested. Discharge of sediment from tile outfalls draining heavy lakebed soils in the Maumee Basin has been previously noted. Subsequently discharge from a 17 ha subsurface drainage system in Hoytville silty clay was monitored. After an initial flush which did not always occur, sediment concentrations tended to remain uniform irrespective of discharge rates. A computer model was calibrated and verified using this discharge data. A comparison laboratory experiment employing intermittent wetting and drying of soil columns showed that Hoytville silty clay (a lake-bed associated soil, 44 percent clay) and Latty silty clay (a lakebed soil, 48 percent clay) discharged approximately 6 and 8 times, respectively, the weight of sediment as discharged from a column of Blount soil loam (a glacial till soil, 30 percent clay). While the sediment discharge from Blount was thought to cause minimal water quality deterioration, that from Latty and Hoytville consisting of colloidal size particles might. Furthermore, this sediment discharge was not reduced using protective envelope materials around the openings from the columns.
(*h*) **Soil Water Modeling II: On Sensitivity to Finite Difference Grid Spacing,** C. R. Amerman, E. J. Monke, *Trans. Amer. Soc. Agric. Engrs.* **20,** 1, pp. 478-484, 1977.
The ANSWERS Model: A Planning Tool for Watershed Research, D. B. Beasley, E. J. Monke, L. F. Huggins, *Amer. Soc. Agric. Engrs., Paper No. 77-2532,* 1977.
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Sediment and Nutrient Contributions to the Maumee River from an Agricultural Watershed, D. W. Nelson, E. J. Monke, A. B. Bottcher, L. E. Sommers, *Proc. 10th Ann. Waste Mgr. Conf.,* Cornell Univ., 1978.
Sediment Contributions to the Maumee River. What Level of Sediment Control is Feasible?, E. J. Monke, R. Z. Wheaton, *Proc. Conf. on Voluntary and Regulatory Approaches for Nonpoint Source Pollution Control,* EPA-905/9-78-001, pp. 170-178, 1978.
Modeling Sediment Yields from Agricultural Watersheds, L. F. Huggins, D. B. Beasley, E. J. Monke, *Proc. 33rd Ann. Meeting Soil Cons. Soc. Amer.,* 1978.
Subsurface Drainage Model with Associated Sediment Transport, A. B. Bottcher, E. J. Monke, L. F. Huggins, *Amer. Soc. Agric. Engrs., Paper No. 78-2502,* 1978.

129-07585-810-33

CHARACTERIZATION OF THE HYDROLOGY OF SMALL WATERSHEDS

(*c*) Dr. L. F. Huggins.
(*d*) Experimental, basic, applied, design.
(*e*) Develop an analytical method to accurately describe the hydrologic response of natural watersheds to real or hypothetical storms independent of gaged records for a watershed.
(*g*) Emphasis is being placed on the development of a distributed parameter watershed model which is capable of simulating both the hydrology and nonpoint source pollution process at all points throughout a complex area. Extensive automated sampling of hydrometeorology conditions in small watersheds varying from 20 ha to 7000 ha is being conducted. Runoff samples are being collected and analyzed for sediment and chemical content.
(*h*) **The ALERT System,** L. F. Huggins, S. J. Mahler, *Environmental Impact of Land Use on Water Quality–Final Report on the Black Creek Project,* EPA-905/9-77-007-B, pp. 76-84, 1977.
Modeling, L. F. Huggins, D. B. Beasley, A. B. Bottcher, E. J. Monke, *Environmental Impact of Land use on Water Quality–Final Report on the Black Creek Project,* EPA-905/9-77-007-B, pp. 177-211, 1977.

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Subsurface Drainage Model with Associated Sediment Transport, A. B. Bottcher, E. J. Monke, L. F. Huggins, *Amer. Soc. Agric. Engrs., Paper No. 78-2502*, 1978.

129-11498-870-36

MONITORING AND MODELING OF AGRICULTURAL NONPOINT SOURCE POLLUTION

(*b*) Agricultural Experiment Station, Purdue University; U.S. Environmental Protection Agency.
(*c*) Dr. D. B. Beasley.
(*d*) Experimental, field investigation, basic research, applied research, design, development.
(*e*) Develop measurement and evaluation techniques for assessing primarily agricultural nonpoint source pollutional problems and for quantifying the effects of various solutions to those problems.
(*g*) Continued development of a distributed parameter hydrologic/water quality model is proceeding. Currently, hydrology and sediment related parameters are being simulated spatially. In addition, continuous records of hydrologic and water quality parameters are being collected in an effort to better understand the naturally occurring processes and to provide a basis for verification of this or other models.
(*h*) **Data Handling and Evaluation and Sediment Delivery Analysis on the Maumee River,** L. E. Sommers, D. W. Nelson, E. J. Monke, D. B. Beasley, A. B. Bottcher, D. Kaminsky, EPA-905/9-75-006, *Environmental Impact of Land Use on Water Quality (Progress Report)*, pp. 63-154, Region V, USEPA, Chicago, 1975.

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ANSWERS: A Mathematical Model for Simulating the Effects of Land Use and Management on Water Quality, D. B. Beasley, *Ph.D. Thesis*, Purdue Univ., 266 p., 1977.

ANSWERS: A Hydrologic/Water Quality Simulator for Watershed Research, D. B. Beasley, L. F. Huggins, *Proc. Winter Simulation Conf., Society of Computer Simulation*, pp. 506-515, 1978.

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PURDUE UNIVERSITY, School of Mechanical Engineering, West Lafayette, Ind., 47907. A. H. Lefebvre, Professor and Head.

130-09841-440-33

LABORATORY SIMULATION OF MIXING IN THERMALLY STRATIFIED, HEATED LAKES, RESERVOIRS AND PONDS

(*b*) Office of Water Research and Technology.
(*c*) Professor R. Viskanta.
(*d*) Experimental and analytical applied research.
(*e*) Obtain basic understanding of the internal mixing and energy transport processes in thermally stratified, shallow natural waterbodies. This is accomplished by performing laboratory experiments under carefully controlled environment simulating as closely as possible the conditions existing in quiescent natural waters such as lakes, reservoirs and ponds. Solar heating and cooling by convection, evaporation as well as radiation are simulated. Internal mixing processes are being visualized using an optical (shadowgraph) technique and the flow field is measured using tracer techniques. The unsteady temperature distribution during heating or cooling of water is determined optically employing a Mach-Zehnder interferometer. This is a unique instrument requiring no probes for temperature determination. Mathematical models are being developed to predict buoyancy driven convective flow and energy transfer resulting from heating by radiation and cooling at the air-water interface to gain understanding of the basic physical processes and to develop modeling capability for complex natural hydraulic systems.
(*g*) A simple thermal model has been used to predict the dynamics of a mixed layer during cooling of a nonuniformly stratified water from the free surface and found to be in good agreement with experimental data. It was determined that the thermal structure in stratified water cooled from above is quite complex and can be separated into several regimes: 1) the skin layer, 2) the thermal boundary layer, 3) the convective (mixed) layer, 4) the interfacial entrainment region, and 5) the stable region.
(*h*) **Interferometric Observations of the Temperature Structure in Water Cooled or Heated from Above,** R. Viskanta, M. Behnia, A. Karalis, *Advances in Water Resources* **1**, pp. 57-69, 1979.

Effects of a Barrier on Temperature Structure and Mixing Thermally Stratified Water Cooled from Above, R. Viskanta, A. Karalis, M. Behnia, *Thermo- and Fluid Dynamics* **11**, pp. 229-239, 1978.

Free Convection in Thermally Stratified Water Cooled from Above, M. Behnia, R. Viskanta, *Intl. J. Heat Mass Transfer* **22**, 1979.

Mixed Layer Growth and Heat Transfer in a Stratified Fluid Heated From Below, M. Behnia, R. Viskanta, *ASME Paper 79-HT, 18th Natl. Heat Transfer Conf.*, Aug. 6-8, 1979, San Diego, Calif.

130-11064-020-00

INVESTIGATION OF COHERENT STRUCTURES IN TURBULENT CHANNEL FLOW

(*c*) Professor W. G. Tiederman.
(*d*) Experimental; basic research; M.S. and Ph.D. theses.
(*e*) Identify efficient, effective and reliable methods for detecting wall layer bursts with velocity sensors. These bursts are discrete eruptions of fluid away from the wall region. Visualization of hydrogen bubble time lines and simultaneous laser velocimeter signals will be used to test various burst detector schemes. The purpose is to provide analysts constructing turbulence models with information about the fundamental motions in the wall region that transport momentum and energy and produce most of the turbulent kinetic energy.

PURDUE UNIVERSITY, School of Nuclear Engineering, West Lafayette, Ind. 47907. Paul S. Lykoudis, Professor and Head.

131-10087-110-54

THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF SINGLE-PHASE AND TWO-PHASE LIQUID METAL FLOWS IN THE PRESENCE OF MAGNETIC FIELDS

(*b*) National Science Foundation.
(*d*) Theoretical and experimental; basic research; M.S. and Ph.D. theses.
(*e*) The Magneto-Fluid-Mechanic Facility at Purdue University consists of isothermal and heat transfer loops in which the liquid medium is mercury. 300 gallons per minute are pumped through test sections simulating turbulent channel flow. An electromagnet with pole faces 12" × 50" provides a magnetic field of 1.5 Tesla at a gap of 3 inches. These loops are in the process of being modifed so that they can accomodate a vertical test-section in which a mixture of mercury-nitrogen will be circulated. The first experiments will be conducted in the bubbly regime and detailed local flow measurements will be made with hot-film anemometry and resistivity probes. Local void fractions, velocities, and slip profiles will be obtained at different cross sections. Pressure drops will also be measured. The work is relevant to liquid metal MHD power generators. Nucleate boiling in liquid metals is being studied in an experimental apparatus consisting of a horizontal heated surface in the presence of a horizontal magnetic field. The boiler has a capability of 300 kw/m^2 heat flux. Platinum resistance thermometers are used for the bulk and surface temperature measurements. Experiments are being conducted with mercury as the working medium (both with and without wetting aditives). This work is relevant for proposed blankets of fusion reactors. Improved thermal mixing in piping components is important in development of Liquid Metal Fast Breeder Reactor systems. During transients sodium streams at temperatures differing up to 400 °F will be mixed in a tee. Due to poor thermal mixing in the tee, large temperature fluctuations will be seen by the walls of the tee resulting in increased probability of failure due to mechanical stresses or thermal fatigue. An experiment is being conducted using water as the working medium in an attempt to understand the phenomena. Work will proceed to the use of mercury as the medium to study effects of the Prandtl number.
(*g*) Hot-film anemometer measurements have been made for bubbles rising in a vertical column of water and the results confirm the data reported in the literature. We are in the process of proceeding with experiments in mercury-nitrogen and then experiments in a magnetic field. Experiments with the liquid metal boiler have been made for boiler pressures of 760 mm Hg, 200 mm Hg and 50 mm Hg in magnetic fields up to 1.26 Tesla. There is a significant effect on boiling heat transfer when a magnetic field is applied. The superheat necessary to maintain nucleate boiling is increased and at 1.26 Tesla, the heat transfer is reduced by 20 percent at 760 mm Hg and by 30 percent at 50 mm Hg. Work continues on a theoretical analysis of bubble growth in a magnetic field. Improved mixing in a piping tee has been obtained through the use of multiple-hole jet plates installed in the inlet legs of the tee. Temperature fluctuations in the tee decrease directly with decreasing available flow area in the inlet.
(*h*) **Turbulence Measurements in Mercury Under the Influence of a Magnetic Field,** C. B. Reed, P. S. Lykoudis, *5th Biennial Symp. Turbulence*, Univ. Missouri at Rolla, Oct. 1977.
The Effect of a Transverse Magnetic Field on Shear Turbulence, C. B. Reed, P. S. Lykoudis, *J. Fluid Mechanics* **89**, 1, pp. 147-171, 1978.
Turbulence Memory in Self-Preserving Wakes, P. M. Bevilaqua, P. S. Lykoudis, *J. Fluid Mechanics* **89**, 3, pp. 589-606, 1978.

131-10089-340-55

PROPAGATION OF THERMAL EXPLOSIONS

(*b*) U.S. Nuclear Regulatory Commission.
(*c*) Professor T. G. Theofanous.
(*d*) Experimental and theoretical, basic research, Doctoral and Masters.
(*e*) Identify the physical processes that govern the triggering and propagation of thermal (vapor) explosions. Towards this end, shock-wave induced fragmentation in liquid/liquid and multiphase systems, as well as shock wave propagation and pressure feedback mechanism are studied.
(*g*) Taylor instability dominated breakup of drops in liquid/liquid systems appears as a relevant mechanism of fragmentation in propagating thermal explosions with molten metals. A formulation for calculating energy exchange during this process is proposed. Additional considerations relevant to the question of criteria for buildup and sustenance of explosions are presented.
(*h*) **Fragmentation of Drops,** T. G. Theofanous, P. D. Patel, *Specialists' Workshop on Predictive Analysis of Material Dynamics in LMFBRs Safety Experiments*, Los Alamos, N.M., Mar. 13-15, 1979.
The Role of Hydrodynamic Fragmentation in Fuel Coolant Interactions, T. G. Theofanous, M. Saito, T. Efthimiadis, 4th CSNI Specialists' Mtg. Fuel Coolant Interactions in Nuclear Reactor Safety, Bournemouth, England, Apr. 2-5, 1979.

131-10091-110-54

TURBULENT STRUCTURE IN NONISOTHERMAL LIQUID METAL

(*b*) National Science Foundation.
(*c*) Professor Alexander Sesonske.
(*d*) Experimental, theoretical, basic; M.S. and Ph.D. theses.
(*e*) To measure the statistical turbulent behavior of the velocity and temperature fields in mercury pipe flow; to use turbulent structure parameters, including turbulent heat flux, and to verify and develop heat transport predictive models. Turbulence measurements were made, using hot-film anemometry, in a flexible heat transfer facility provided with various test section flow and temperature traversing arrangements.
(*f*) Suspended.
(*g*) Turbulent structure measurements were made at $Re=10^5$ and with a constant wall heat flux of 23 kW/m^2. Heat and momentum transport parameters were investigated using cross-spectral and auto-correlation techniques. Scale behavior was studied.
(*h*) **Turbulent Structure Measurements and Thermal Transport Modeling in Liquid Metals,** L. L. Eyler, *Ph.D. Thesis*, May 1978. Available University Microfilms.

131-11433-340-52

THE TERMINATION PHASE OF CORE DISRUPTIVE ACCIDENTS IN LMFBRs

(*b*) Argonne National Laboratory (Dept. of Energy).
(*c*) Professor T. G. Theofanous.
(*d*) Experimental and theoretical, basic, Doctoral and Masters.
(*e*) Investigate the fundamentals of transient interactions between a high pressure flashing liquid discharge and a volatile liquid pool. Of particular interest are hydrodynamic instabilities that lead to entrainment and associated energy transfer processes.
(*g*) The most significant finding of this work is that the presence of entrainment during bubble growth was found significantly less than expected on the basis of the current literature. A small amount of entrainment is seen as the impact is approached and a new entrainment mechanism is suggested. Additional study of this region will be required to predict the extent of entrainment and quantify its impace on energy release.
(*h*) **The Termination Phase of Core Disruptive Accidents in LMFBRs,** M. Saito, T. G. Theofanous, *Specialists' Workshop on Predictive Analysis of Material Dynamics in*

LMFBR Safety Experiments, Los Alamos, N.M., Mar. 3-13, 1979.
The Termination Phase of Core Disruptive Accidents in LMFBRs, T. G. Theofanous, M. Saito, D. Christopher, J. Beecher, *3rd Quarterly Progress Rept., PNE-78-138.*

THE RAND CORPORATION, Engineering and Applied Sciences Department, 1700 Main Street, Santa Monica, Calif. 90406. Dr. E. C. Gritton, Department Head. (Publications may be purchased.)

132-08952-400-33

DEVELOPMENT OF A THREE-DIMENSIONAL MODEL FOR ESTUARIES AND COASTAL SEAS

(*b*) Department of the Interior, Office of Water Research and Technology.
(*c*) Dr. J. J. Leendertse.
(*d*) Experimental and theoretical; applied research and development.
(*e*) Develop a finite difference model which can be used to compute the flow in estuaries and coastal sea systems with anisotropic densities. The model is intended to be used in engineering and scientific investigations of estuaries with complicated bathymetry and flow patterns.
(*f*) Completed.
(*g*) A three-dimensional finite difference model has been developed which contains an equation of continuity, equations describing conservation of momentum, salt, heat, subgridscale turbulent energy, and an equation of state. In the model vertical accelerations, but not the vertical velocites and transports, are neglected. The vertical exchange coefficients are computed from the subgridscale turbulent energy intensity. Numerical experiments using San Francisco Bay, Chesapeake Bay, Long Island Sound, Lake Michigan, and Bay of Georgia were performed.
(*h*) **A Three-Dimensional Model for Estuaries and Coastal Seas: Volume IV, Turbulent Energy Computation,** J. J. Leendertse, S. K. Liu, *The Rand Corporation R-2187-OWRT*, May 1977.
A Three-Dimensional Model for Estuaries and Coastal Seas: Volume V, Turbulent Energy Program, S. K. Liu, A. B. Nelson, *The Rand Corporation R-2188-OWRT*, May 1977.

132-09908-010-18

LAMINAR FLOW HYDRODYNAMICS

(*b*) Defense Advanced Research Projects Agency.
(*c*) Dr. E. C. Gritton.
(*d*) Theoretical; basic and applied.
(*e*) With the purpose of obtaining extended regions of laminar flow and accompanying low hydrodynamic drag, this is an investigation of the effects of pressure gradient, heat transfer, and other means of boundary-layer control on the development, stability, and transition of water boundary layers.
(*g*) Analytical and numerical studies have been made of water boundary layers with combined pressure gradient and heat transfer. The results provide the basis for predicting the effects of flow geometry and heat transfer on hydrodynamic performance.
(*h*) **The Buoyancy and Variable Viscosity Effects on a Water Laminar Boundary Layer Along a Heated Longitudinal Horizontal Cylinder,** L. S. Yao, I. Catton, *The Rand Corporation, R-1966-ARPA*, Feb. 1977.
e^9: Stability Theory and Boundary-Layer Transition, S. A. Berger, J. Aroesty, *The Rand Corporation, R-1898-ARPA*, Feb. 1977.
Entry Flow in a Heated Tube, L. S. Yao, *The Rand Corporation R-2111-ARPA*, June 1977; also published in *J. Fluid Mechanics* **88**, 3, pp. 465-483, 1978.
The Effects of Unsteady Potential Flow on Heated Laminar Boundary Layers in Water: Flow Properties and Stability, W. S. King, J. Aroesty, L. S. Yao, W. Matyskiela, *The Rand Corporation R-2164-ARPA*, Nov. 1977.
Approximate Methods for Calculating the Properties of Heated Laminar Boundary Layers in Water, G. M. Harpole, S. A. Berger, J. Aroesty, *The Rand Corporation R-2165-ARPA*, Jan. 1978; to be published in *J. Applied Mechanics, Trans. ASME.*
Simple Relations for the Stability of Heated Laminar Boundary Layers in Water: Modified Dunn-Lin Method, J. Aroesty, W. S. King, G. M. Harpole, W. Matyskiela, A. R. Wazzan, C. Gasley, Jr., *The Rand Corporation R-2209-ARPA*, Mar. 1978; accepted for publication in *Physics of Fluids.*
The Combined Effects of Pressure Gradient and Heating on the Stability and Transition of Boundary Layers in Water, A. R. Wazzan, C. Gazley, Jr., *The Rand Corporation R-2175-ARPA*, Mar. 1978; also published in *Proc. 2nd Intl. Conf. Drag Reduction*, Aug. 31, 1977-Sept. 2, 1977, (*Paper E-3*).
The Combined Effects of Pressure Gradient and Heating on the Stability of Freon 114 Boundary Layers, A. R. Wazzan, C. Gazley, Jr., H. Taghavi, W.-C. Hsu, *Physics of Fluids* **21**, 12, pp. 2141-2147, Dec. 1978.
Tollmien-Schlichting Waves and Transition–Part I. Heated and Adiabatic Wedge Flows with Application to Bodies of Revolution, A. R. Wazzan, C. Gazley, Jr., A. M. O. Smith, *Progress in Aerospace Sciences* **18**, pp. 351-392, 1979.

132-09909-870-52

ATMOSPHERIC EFFECTS OF LARGE POWER-GENERATING FACILITIES

(*b*) Department of Energy.
(*c*) Dr. L. Randall Koenig.
(*d*) Theoretical: applied research.
(*e*) Investigate the possibility that rejection to the atmosphere of large amounts of waste heat can induce the development of large-scale convective cloudiness and precipitation. Two approaches are used, the study of natural and industrial analogs, and development of hydrodynamical atmospheric models.
(*g*) Conditions under which cooling tower plumes glaciate and cause snowfall have been defined through field observations of others. Numerical simulation of plume microphysical process provides predictions of snowfall amount. Numerical model of atmospheric convective cloudiness and precipitation has been checked against observations of anomalous cloudiness spawned by a refinery. Model for effects for large heat rejection to the atmosphere continues under development.
(*h*) **Differences in Atmospheric Convection Caused by Waste Energy Rejected in the Forms of Sensible and Latent Heats,** L. R. Koenig, F. W. Murray, P. M. Tag, *Atmospheric Environment* **12**, pp. 1013-1019, 1978.
Numerical Simulation of an Industrial Cumulus and Comparison with Observations, F. W. Murray, L. R. Koenig, P. M. Tag, *J. Applied Meteorology* **17**, pp. 655-660, 1978.
Self-Precipitation of Snow from Cooling Towers, Preprint Volume: Conference on Cloud Physics and Atmospheric Electricity, July 31-Aug. 4, 1978, Issaquah, Washington, published by the Amer. Meteorological Soc., pp. 426-429, 1978.

132-09910-270-40

MATHEMATICAL MODELS FOR STUDYING SICKLE CELL DISEASE

(*b*) National Institutes of Health.
(*c*) Dr. William S. King.
(*d*) Theoretical.
(*e*) Develop mathematical models and computer simulations to examine the interplay among the fluid mechanics of the microcirculatory system, blood chemistry, oxygen transport phenomena, and red cell sickling. Particular emphases are placed on modeling the blockage of capillaries by sickled red blood cells. The ultimate goal is to simulate mathematically a vascular occlusive crisis.

(*g*) Analytical models have been developed to study the physicochemical aspect of the sickling process as well as the kinetics of sickling. These models are being incorporated into our capillary flow models.

(*h*) **Therapeutic Implications of Physicochemical Phenomena Involved in Sickle Cell Disease,** J. C. DeHaven, *The Rand Corporation R-1974-HEW*, Apr. 1976.

Hematological Compensation During Treatment of Sickle-Cell Anemia: A Simple Mathematical Model, *The Rand Corporation R-1952-HEW*, Dec. 1976.

A Mathematical Model of the Effect of Oxygen Consumption on the Resistance to Flow of Sickle Cell Blood in Capillaries, D. O. Loman, J. F. Gross, *Mathematical Biosciences* **37**, pp. 63-79, 1977.

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132-11065-450-44

MODELING OF TIDES AND CIRCULATIONS OF THE BERING SEA

(*b*) Department of Commerce, National Oceanic and Atmospheric Administration.

(*c*) Drs. J. J. Leendertse, S. K. Liu.

(*d*) Experimental and theoretical; applied research and development.

(*e*) The primary purpose of the study is to develop two three-dimensional finite difference models covering the areas of Bristol Bay, St. George Basin, and Norton Sound, Alaska. These models, after adjustment and verification, will serve as a basis for predicting oil spill trajectories and for risk analyses. The ice movements within these coastal waters are also being studied.

(*f*) Continuing.

(*g*) The model covering the areas of Bristol Bay and St. George Basin has been verified using field data corrected by NOAA. The computed current field from predicted tides at the open boundaries agrees with the observed values in the modeled areas.

(*h*) **A Three-Dimensional Model for Estuaries and Coastal Seas: Volume VI, Bristol Bay Simulations,** S. K. Liu, J. J. Leendertse, *The Rand Corporation R-2405-NOAA*, Apr. 1979.

Three-Dimensional Subgridscale Energy Model of Eastern Bering Sea, S. K. Liu, J. J. Leendertse, *Proc. 16th Intl. Conf. Coastal Engrg., ASCE*, 1979.

132-11066-400-30

THE SIMSYS/WAQUA SYSTEM FOR TWO-DIMENSIONAL MODELING OF ESTUARIES AND COASTAL SEAS

(*b*) Data Processing Division, Netherlands Rijkswaterstaat, and the Water Resources Division, United States Geological Survey.

(*c*) Dr. ir. J. J. Leendertse.

(*d*) Experimental and theoretical; applied research and development.

(*e*) Development of a reliable, broadly applicable and economically useful two-dimensional modeling system to simulate flows and water-quality conditions in estuaries and coastal seas. Finite difference approximations of the equations of motion, continuity equations, and mass balance equations are used. The model can be operated with all terms, except the viscosity term, as second-order terms. The system permits many time-varying discharges, open boundary representation by Fourier components or time series of water levels or velocities, coupling through an equation of state between salinity and pressure and time- and spatially-varying air pressure and wind inputs. Graphical representation of flow fields, constituent distribution fields and time-varying model results can be obtained which are suitable for reproduction in agency reports.

(*g*) Different versions of the system are in operational use by sponsors and by Rand.

132-11067-400-87

MODEL STUDY OF THE EASTERN SCHELDT AND ADJACENT COASTAL WATERS

(*b*) Delta Service of the Netherlands Rijkswaterstaat.

(*c*) Dr. ir. J. J. Leendertse.

(*d*) Experimental and applied research.

(*e*) Model investigation to determine the impact on water levels, currents and water quality of the construction and operation of a storm surge barrier across the Eastern Scheldt and the effect of secondary closure dams in this estuary. Two groups of two-dimensional finite difference models are used. The Randdelta II model (grid size 800m, dim. 147×107 points) covers, in addition to the Eastern and Western Scheldt, a large offshore area. This model computes boundary conditions for models of subsections of the system with grid sizes of 800m and 400m. The models have the capability of reproducing tides, storm surges, current, salinity and water-quality parameter distributions resulting from many discharges into the system and different barrier operating strategies.

(*h*) **Adjustment and Verification of the Randdelta II Model,** A. Langerak, M. A. M. De Ras, J. J. Leendertse, *Proc. 16th Intl. Conf. Coastal Engrg., ASCE*, 1979.

A Tidal Survey for a Model of an Offshore Area, W. J. van de Ree, J. Voogt, J. J. Leendertse, *Proc. 16th Intl. Conf. Coastal Engrg., ASCE*, 1979.

RENSSELAER POLYTECHNIC INSTITUTE, Department of Mathematical Sciences, Troy, N. Y. 12181. Dr. Richard C. DiPrima, Department Chairman.

133-06772-000-20

VISCOUS FLOW STABILITY

(*b*) Office of Naval Research.

(*c*) Professor R. C. DiPrima.

(*d*) Theoretical; basic research.

(*e*) Various effects, particularly stability, are studied in an effort to achieve basic understanding of fluid flows which have importance in applications.

(*g*) A notable result is a unified treatment of the instability mechanisms associated with Benjamin-Feir and with Eckhaus. A corrected and extended form of the latter result has been found for the general case of complex eigenvalues and complex coefficients in the slowly-changing (in space and time) amplitude of the fundamental. Progress has been made in the study of effects of axial flow, of ends, and of rapid inner cylinder rotation on the Taylor instability problem. Also see 133-06773-000-14.

(*h*) **The Effects of Eccentricity on Torque and Load in Taylor-Vortex Flow,** P. M. Eagles, J. T. Stuart, R. C. DiPrima, *J. Fluid Mechanics* **87**, pp. 209-231, 1978.

The Eckhaus and Benjamin-Feir Resonance Mechanism, J. T. Stuart, R. C. DiPrima, *Proc. R. Soc. Lond.* **362**, pp. 27-41, 1978.

Effect of a Coriolis Force on the Stability of Plane Poiseuille Flow, J. E. Flaherty, R. C. DiPrima, *Physics of Fluids* **21**, pp. 718-726, 1978.

Asymptotic Methods for a General Finite Width Gas Slider Bearing, J. A. Schmitt, R. c. DiPrima, *J. Lubrication Technology* **100**, pp. 254-260, 1978.

Amplification Rates and Torques for Taylor-Vortex Flow between Rotating Cylinders, R. C. DiPrima, P. M. Eagles, *Physics Fluids* **20**, pp. 171-175, 1977.

The Force on a Small Sphere in Slow Viscous Flow, D. A. Drew, *J. Fluid Mechanics* **88**, pp. 393-400, 1978.

Lubrication Flow of a Particle-Fluid Mixture, D. A. Drew, *J. of Applied Mechanics* **46**, pp. 211-213, 1979.

133-06773-000-14

ANALYSIS OF NONLINEAR PROBLEMS IN FLUID MECHANICS

(*b*) U.S. Army Research Office.

(*c*) Professors R. C. DiPrima, L. A. Segel.
(*d*) Theoretical; basic research.
(*e*) Investigation of nonlinear mathematical problems arising in fluid mechanics (particularly stability problems) and in physical chemistry.
(*g*) Work has centered on (1) deepening the study of Taylor vortex flow, (2) examination of Stokeslets in bounded domains, (3) elucidating certain basic phenomena in nonlinear stability to problems in electrophysics that arise in connection with electrodialysis (a method of desalination). Also see 133-06772-000-20.
(*h*) **Amplification Rates and Torques for Taylor-Vortex Flows between Rotating Cylinders,** R. C. DiPrima, P. M. Eagles, *Physics of Fluids* **20,** pp. 171-175, 1977.
Nonlinear Dynamic Theory for a Double-Diffusive Convection Model, L. A. Rubenfeld, W. L. Siegmann, *SIAM J. of Applied Math.* **32,** pp. 871-894, 1977.
Asymptotic Methods for a General Finite Width Gas Slider Bearing, J. A. Schmitt, R. C. DiPrima, *J. Lubrication Technology* **100,** pp. 254-260, 1978.
Effect of a Coriolis Force on the Stability of Plane Poiseuille Flow, J. E. Flaherty, R. C. DiPrima, *Physics of Fluids* **21,** pp. 718-726, 1978.
Stokes Flow Due to a Stokeslet in a Pipe, N. Liron, R. Shahar, *J. Fluid Mechanics* **86,** pp. 727-744, 1978.
The Eckhaus and Benjamin-Feir Resonance Mechanism, J. T. Stuart, R. C. DiPrima, *Proc., R. Soc. Lond.* **A362,** pp. 27-41, 1978.
The Effects of Eccentricity on Torque and Load in Taylor-Vortex Flow, P. M. Eagles, J. T. Stuart, R. C. DiPrima, *J. Fluid Mechanics* **87,** pp. 209-231, 1978.
An Introduction to Continuum Theory, L. A. Segel, *Modern Modeling of Continuum Phenomena, Lectures in Applied Mathematics* **16,** 1977, Amer. Mathematical Soc., Providence, R.I.

UNIVERSITY OF ROCHESTER, Department of Mechanical and Aerospace Sciences, Rochester, N.Y. 14627. Professor Alfred Clark, Jr., Chairman.

134-09960-450-00

ROSSBY WAVES ON A MULTIPLE BETA-PLANE

(*c*) John H. Thomas, Assoc. Professor.
(*d*) Theoretical investigation; basic research.
(*e*) A multiple beta-plane is introduced to simulate the variation of the Coriolis parameter with latitude. The problem of reflection and refraction of plane Rossby waves at a discontinuity in beta has been solved. The multiple beta plane leads to Rossby waves trapped in a band about the equator, as is the case on the full sphere. Related laboratory experiments are planned.
(*h*) **Refraction of Rossby Waves on a Multiple Beta-Plane,** J. H. Thomas, R. A. Lux, *Dynamics of Atmospheres and Oceans* **2,** pp. 411-426 (1978).

134-09965-000-54

FLOW IN PARTIALLY-FILLED CYLINDERS

(*b*) National Science Foundation.
(*c*) Roger F. Gans, Assoc. Professor.
(*d*) Experimental, theoretical; basic research, thesis.
(*e*) A continuing effort to understand stability and nonlinear phenomena observable in a partially-filled cylinder with its rotation axis horizontal. Interest is presently focused on the dynamics near the interface, and how these are influenced by interfacial phenomena.
(*g*) A steady-state, nonlinear, viscous analysis of the flow has been completed. Careful measurements of the flow at the air-water interface have been made. Additional analyses and experiments on nonideal free surfaces are in progress.
(*h*) **On Steady-State Flow in a Partially-Filled Rotating Cylinder,** R. F. Gans, *J. Fluid Mech.* **82,** 415 (1977).
Flow Measurements in a Partially-Filled Rotating Cylinder, R. F. Gans, S. Yalisove, *Bull. Am. Phys. Soc.* **23,** 989 (1978).
An Experimental Study of Steady Flow in a Partially Filled Rotating Cylinder, R. D. Whiting *Dissertation,* Dept. of Mech. and Aerospace Sciences, Univ. of Rochester (1978).
On the Flow Around a Buoyant Cylinder Within a Rapidly Rotating Cylindrical Container, R. F. Gans, *J. Fluid Mech.,* (in press).

134-11068-270-40

EXPERIMENTAL STUDY OF FLOW IN CONSTRICTED PIPES

(*b*) Basic Research Support Grants, N.I.H.
(*c*) R. F. Gans.
(*d*) Experimental, basic research.
(*e*) Laser Doppler anemometer study of flow in an exponential constriction to assess theoretical and numerical results in the literature.

RUTGERS UNIVERSITY, The State University of New Jersey, College of Engineering, Department of Mechanical, Industrial and Aerospace Engineering, Piscataway, N.J. 08854. Dr. C. F. Chen, Department Chairman.

135-07616-090-00

SEPARATED FLOWS

(*c*) Professor R. H. Page and Assoc. Professor C. E. G. Przirembel.
(*d*) Experimental and theoretical basic research.
(*e*) Basic research in separated flows is being carried out to determine a much more fundamental understanding of the thermodynamic and dynamic mechanisms.
(*g*) Special experimental research facilities have been developed and theoretical models of various separated or separating flows have been formulated.
(*h*) **Rear Stagnation Point Location in a Subsonic Near-Wake,** R. A. Merz, R. H. Page, C. E. G. Przirembel, *J. Spacecraft and Rockets* **13,** 5, pp. 319-320, May 1976.
Techniques for Visualization of Separated Flows, R. H. Page, C. E. G. Przirembel, *Proc. Intl. Symp. Flow Visualization,* Tokyo, pp. 235-240, Oct. 1977.
The Turbulent Flow Through a Sudden Enlargement at Subsonic Speeds, S. Kangovi, R. H. Page, *Proc. 6th Australian Hydraulics and Fluid Mechanics Conf.,* Univ. of Adelaide, Australia, Dec. 1977.
Subsonic Axisymmetric Near-Wake Studies, R. A. Merz, R. H. Page, C. E. G. Przirembel, *AIAA J.* **16,** 7, pp. 656-662, 1978.
The Effect of Base Bleed/Suction on the Subsonic Near-Wake of a Bluff Body, C. E. G. Przirembel, *Proc. ASME Symp. Aerodynamics of Transportation,* 1979 ASME Fluids Engrg. Div. Conf., Niagara Falls, N.Y., June 1979.

135-07618-720-80

EMIL BUEHLER WIND TUNNEL

(*b*) Emil Buehler Foundation.
(*c*) Professor R. H. Page.
(*d*) Design; development.
(*e*) Design, operation, and development, of a supersonic variable Mach number wind tunnel and auxiliary apparatus for teaching and research programs. A variable Mach number wind tunnel (up to Mach 4.0) has been used extensively since it was first operated on April 21, 1964. It is used for teaching and research programs.
(*g*) Improvements in the tunnel's operation have been continuously made.
(*h*) **Aerothermodynamic Base Heating,** Y. Inoue, R. H. Page, *Progress in Astronautics and Aeronautics* **59,** AIAA, New York, N.Y., 1978.

An Approximate Analysis of the Supersonic Turbulent Base Heat Transfer with Special Regard to the Effect of the Boundary Layer Thickness, Y. Inoue, R. H. Page (in Japanese), Natl. Aerospace Lab., Tokyo, *NAL TR-497*, Apr. 1977.
Effects of Thick Boundary Layers on Supersonic Turbulent Base Heat Transfer, Y. Inoue, R. H. Page, *Proc. 6th Canadian Congress of Applied Mechanics*, Univ. British Columbia, pp. 567-568, May 1977.
Subsonic Turbulent Base Drag, R. H. Page, *Proc. 14th Southeastern Sem. Thermal Sciences*, N.C. State Univ., pp. 348-363, Apr. 1978.

135-07619-600-00

FLUIDICS RESEARCH

(*c*) Professor R. H. Page.
(*d*) Theoretical and experimental investigations.
(*e*) Theoretical analyses of separating and reattaching flows are being carried out and verified with specially designed experiments.
(*g*) Basic fluid mechanics of separation and reattachment of fluidic devices has been formulated.

135-08950-290-15

ANALYSIS OF RESONANCE TUBES

(*b*) Rutgers Research Council.
(*c*) Associate Professor C. E. G. Przirembel.
(*d*) Experimental, theoretical; basic research.
(*e*) The flow fields associated with two-dimensional and axisymmetric resonance tubes are being investigated. The test parameters, which are being varied in the experimental program, are the nozzle jet stagnation pressure, the separation distance between the nozzle and the resonance tube entrance, and the relative length of the resonance tube. Time-dependent and time-averaged pressures and temperatures are being obtained in the resonance tube. Color Schlieren, Schlieren and shadowgraph flow visualization techniques, in conjunction with high speed motion picture techniques, are used in observing and analyzing the jet and resonance tube flow fields.
(*h*) **Thermodynamic Characteristics of a Blunt, Two-Dimensional Resonance Tube,** C. E. G. Przirembel, L. S. Fletcher, E. E. Wolf, *AIAA J.* **15,** 7, p. 905, July 1977.
Visual Studies of Resonance Tube Phenomenon, C. E. G. Przirembel, R. H. Page, D. E. Wolf, *Proc. Intl. Symp. Flow Visualization*, Tokyo, Japan, p. 205, Oct. 1977.
Aerothermodynamic Characteristics of a Resonance Tube Driven by a Subsonic Jet, C. E. G. Przirembel, L. S. Fletcher, *AIAA J.* **16,** 2, p. 184, Feb. 1978.
Aerothermodynamic Aspects of an Axisymmetric Resonance Tube, C. E. G. Przirembel, G. R. Andre, *AIAA Paper No. 78-859, 2nd AIAA/ASME Thermophysics and Heat Transfer Conf.*, Palo Alto, Calif., May 1978.
Transient Analysis of the Aerothermodynamic Characteristics of a Resonance Tube, C. E. G. Przirembel, D. E. Wolf, G. R. Andre, *AIAA Paper No. 79-1050, 14th AIAA Thermophysics Conf.*, Orlando, Fla., June 1979.

135-10127-020-54

DOUBLE-DIFFUSIVE CONVECTION

(*b*) National Science Foundation.
(*c*) Professor C. F. Chen.
(*d*) Experimental and theoretical; basic research.
(*e*) Investigate the stability of double-diffusive convection in an inclined fluid layer and to assess the effect of double-diffusive effects in thermal dispersion.
(*g*) In an inclined fluid layer with density stratification, heating from above is less stable than heating from below. This and other interesting results are reported in the following publications.
(*h*) **Stability of Time Dependent Double-Diffusive Convection in an Inclined Slot,** C. F. Chen, R. D. Sandford, *J. Fluid Mech.* **83,** pp. 83-96, 1977.
Double-Diffusive Instability in a Density Stratified Fluid Along a Heated Inclined Wall, C. F. Chen, *J. Heat Trans.* **100,** pp. 653-658, 1978.
Double-Diffusive Convective Instability of an Inclined Fluid Layer, R. C. Paliwal, *Ph.D. Thesis*, Dept. of Mechanical, Industrial, and Aerospace Engrg., Rutgers Univ., Mar. 1979.

135-10129-010-26

BOUNDARY LAYER SEPARATION FROM A SLENDER BODY AT HIGH ANGLES OF ATTACK

(*b*) Air Force Office of Scientific Research (AFSC).
(*c*) Assoc. Professor C. E. G. Przirembel.
(*d*) Experimental and theoretical.
(*e*) The three-dimensional boundary layer separation process and the roll-up of the associated free-shear layer, which characterize the flow field in the vicinity of a slender body at moderate to high angles of attack, are being investigated. The improved understanding of these flow characteristics will assist in the rational modification of existing numerical calculations of aerodynamic forces and moments for slender bodies at high angles of attack.
(*h*) **Aerodynamics of Slender Bodies at High Angles of Attack,** C. E. G. Prziremble, D. E. Shereda, *J. Spacecraft and Rockets* **16,** 1, p. 10, Jan.-Feb. 1979.
Boundary Layer Separation from a Slender Body at High Angles of Attack, C. E. G. Przirembel, D. T. G. Wen, Mechanical, Industrial, and Aerospace Engrg. Dept., Rutgers Univ. RU-TR 151 MIAE-F, AFOSR-TR-79-0022, Oct. 1978.

135-10130-060-54

COUETTE INSTABILITY OF STRATIFIED FLUIDS

(*b*) National Science Foundation.
(*c*) Professor C. F. Chen.
(*d*) Experimental and theoretical; basic research.
(*e*) Investigate couette instability of stably stratified fluid between two concentric rotating cylinders both experimentally and theoretically. Experiments have been carried out for $\eta = 0.925$ case where η is the radius ratio. Work is going on for $\eta = 0.5$ case. Linear stability analysis for asymmetric disturbances will be carried out.
(*g*) For the small gap case, the critical conditions for the stratified fluid are not too different from those for the homogeneous case. For $\eta = 0.5$ density stratification effects are much more pronounced.

135-11069-020-54

TURBULENCE MODELS AND LARGE SCALE STRUCTURES IN TURBULENT SHEAR FLOWS

(*b*) National Science Foundation.
(*c*) Asst. Professor D. D. Knight.
(*d*) Theoretical.
(*e*) The two-dimensional unsteady turbulent mixing layer is investigated theoretically using a model for the fine scale turbulence. Specific areas of interest are the dynamics of large scale ("coherent") structure growth and amalgamation, entrainment, and energy transfer between large and fine scales.
(*g*) Preliminary results indicate quantitative agreement with the observed mean growth rate of the mixing layer and the self-similarity of the mean velocity profile. The results display the observed phenomena of "pairing" of large-scale structures in qualitative agreement with experiment.
(*h*) **Numerical Investigation of Large Scale Structures in the Turbulent Mixing Layer,** D. D. Knight, P. G. Saffman, *8th U.S. Natl. Congress Theoretical and Applied Mechanics*, June 1978.

135-11070-540-27

HIGH SPEED AIRCRAFT INLETS WITH STRONG VISCOUS-INVISCID INTERACTIONS

(*b*) U.S. Air Force.
(*c*) Asst. Professor D. D. Knight.

(*d*) Theoretical.
(*e*) A computer code is developed to solve the flowfield in high speed inlets with strong viscous-inviscid interactions. The full Navier-Stokes equations are employed with an algebraic eddy viscosity model.
(*g*) Substantial improvements in efficiency have been achieved through a variety of numerical techniques.
(*h*) **Numerical Simulation of Realistic High Speed Inlets Using the Navier-Stokes Equations,** *AIAA J.* **15**, pp. 1583-1589, Nov. 1977.

135-11071-030-54

UNSTEADY DROPLET MOTION

(*b*) National Science Foundation.
(*c*) Professor S. Temkin.
(*d*) Experimental and theoretical; basic research.
(*e*) Determine the effects of unsteadiness on the drag coefficient for small spheres. Our earlier work showed that when the free stream velocity around the sphere decelerates in time, the drag on the sphere increases. To observe both acceleration and deceleration, we have built a facility which produces N-waves. This is being used to set uniform streams of small (80-200 μm) droplets into motion.
(*g*) Preliminary results obtained with non-deforming droplets show that, as before, the drag is larger than the steady when the relative fluid velocity decelerates, and is smaller than the steady when it accelerates.
(*h*) **Droplet Drag in Shock-Induced Flowfields,** S. Temkin, S. S. Kim, *Bull. Amer. Phys. Soc.* **22,** 1292 (1977).
Droplet Motion Induced By N Waves, *J. Acoust. Soc. Amer.* **64,** Suppl. I, 513 (1978).

135-11072-090-00

CONVECTION IN SPHERICAL SHELLS

(*c*) Asst. Professor A. Zebib.
(*d*) Theoretical; basic research.
(*e*) Natural convection in an infinite Prandtl number fluid subjected to a spherically symmetric gravity field in a spherical shell is considered. Two models of heating are investigated. In the first, thermal energy is produced in the core, and in the second, thermal energy is also uniformly generated within the fluid. Heat transfer characteristics and resulting cellular motion of stable, finite amplitude convection are determined.
(*g*) A class of axisymmetric convective motion was shown to be the stable form of convection for modestly supercritical Rayleigh numbers in a relatively thick spherical shell heated from below. However, at onset of convection the preferred convective motion is three-dimensional.
(*h*) **Infinite Prandtl Number Thermal Convection in a Spherical Shell,** A. Zebib, G. Schubert, J. M. Strauss. Submitted for publication in J. Fluid Mech.

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SCRIPPS INSTITUTION OF OCEANOGRAPHY, University of California, San Diego, La Jolla, Calif. 92093.

136-10394-420-44

STEADY STREAMING AROUND CIRCULAR BODIES UNDER LINEAR SURFACE WAVES

(*b*) NOAA, Sea Grant.
(*c*) Dr. Douglas L. Inman or Scott Jenkins (graduate student).
(*d*) Experimental and theoretical, basic research with design considerations approached.
(*e*) Measurements of the forces resulting from laboratory scale waves on submerged spheres and cylinders. Measurements of the drift currents produced around these bodies with unseparated flow. Theoretical descriptions for these steady currents are being developed through successive approximations to the wave boundary layer equations.
(*g*) The streaming gives rise to Kutta-Joukowski forces which reduce the resultant of the wave pressure. The streaming has been described approximately by boundary layer theory for a flow regime limited to unseparated motion. Long chain polymer surfaced bodies exhibit reduced streaming.
(*h*) **Forces on a Sphere Under Linear Progressive Waves,** Jenkins and Inman, *Proc. 15th Intl. Conf. on Coastal Engrg., ASCE* **3**, 1976.

136-11638-410-44

MODELING SEDIMENT TRANSPORT ON BEACHES

(*b*) NOAA Sea Grant.
(*c*) Dr. James A. Bailard.
(*d*) Theoretical basic research.
(*e*) Investigation of a bed load and suspended load sediment transport dynamics on planar sloping beaches using energetics principles.
(*g*) High arch moments of the near bottom velocity distribution and nonlinear interactions between steady and oscillatory currents, are found to play important roles in the sediment transport dynamics on beaches.
(*h*) **An Energetics Based Model for the Transport of Bedload Sediment over a Planar Sloping Beach,** J. A. Bailard, *J. Geophysical Research*, in review.

136-11639-220-22

INNOVATIVE SEDIMENT MANAGEMENT TECHNIQUES

(*b*) U.S. Naval Facilities Engineering Command; NOAA Sea Grant, U.S. Army Corps of Engineers, Waterways Experiment Station.
(*c*) Dr. Douglas L. Inman, Dr. William Van Dorn, Dr. James A. Bailard.
(*d*) Combined experimental, theoretical and field applied research.
(*e*) Development of innovative systems to reduce the cost of dredging fine and coarse sediments from harbors. Systems studies include jet arrays, curtain barriers, crater-sinks, fluidization sand bypassing and porous sand fences.
(*g*) Scaling laws verified, predictive models developed, prototypes successfully tested.
(*h*) **Coastal Wetlands Management: A Systems Approach to Opening and Maintenance of Lagoon Inlets Using Sand Fluidization,** D. L. Inman, J. A. Bailard, *University of California Sea Grant Annual Report*, in press.
The Evaluation of Sediment Management Procedures, Phase III, Final Report 1976-1977, W. G. Van Dorn, D. L. Inman, S. S. McElmury, University of Calif., Scripps Inst. of Oceanography, (1978).
Coastal Wetlands Management: A Systems Approach to Opening and Maintenance of Lagoon Inlets Using Sand Fluidization, D. L. Inman, R. E. Flick, *University of California Sea Grant Annual Report*, 1978.
The Evaluation of Sediment Management Procedures, Phase II Final Report, 1975-1976: University of California, W. G. Van Dorn, D. L. Inman, R. W. Harris, S. S. McElmury, *Scripps Institution of Oceanography, Reference Series 77-10*, 107 pp., (1977).
Study and Evaluation of Remedial Sand Bypassing Procedures, R. W. Harris, D. L. Inman, J. A. Bailard, R. Oda, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Miss., *Contract Report H076-1*, 128 pp., 1976.
The Evaluation of Sediment Management Procedures, Phase I Final Report, 1974-1975: University of California, W. G. Van Dorn, D. L. Inman, R. W. Harris, *Scripps Institution of Oceanography, Reference Series 75-32*, 82 pp., (1975).

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UNIVERSITY OF SOUTH CAROLINA, Belle W. Baruch Institute for Marine Biology and Coastal Research, Columbia, S.C. 29208. Dr. F. John Vernberg, Director.

137-11073-400-54

MATERIAL FLUXES THROUGH A TIDAL SALT MARSH ESTUARY: AN ECOSYSTEM STUDY IN OUTWELLING

(*b*) National Science Foundation.
(*c*) Field investigation; basic research.
(*e*) Obtain seasonal data on flux rates of materials between North Inlet Estuary and Atlantic Ocean. Synoptic sampling over a ten-day period by a crew of about ninety field investigators. Objective: to provide evidence for outwelling or inwelling phenomenon in estuarine system.
(*g*) See publications below.
(*h*) **Material Fluxes Through the North Inlet Marsh System: Short Term Temporal Fluctuations of Fungi and Related Parameters,** T. H. Chrzanowski, L. H. Stevenson, *Mycologia*, (in press).
Material Fluxes Through the North Inlet Marsh System: Characterization of a Large Creek in Terms of Adenosine 5′-Triphosphate, *Appl. Environ. Microbiol.*, (in press).
Low-Frequency Response of Estuarine Sea Level to Non-Local Forcing, B. Kjerfve, J. E. Greer, L. R. Crout. In: *Estuarine Interactions*, M. L. Wiley (ed.), Academic Press, pp. 497-513, 1978.

UNIVERSITY OF SOUTH CAROLINA, Department of Civil Engineering, Columbia, S.C. 29208. J. D. Waugh, Dean, College of Engineering.

138-11718-870-27

REVIEW OF TOXIC SPILL MODELING

(*b*) U.S. Air Force, Research and Development Directorate, Air Force Engineering Services Center, Tyndall Air Force Base, Fla. 32403.
(*c*) Dr. Barry A. Benedict, Associate Professor.
(*d*) Theoretical; applied research.
(*e*) This work is intended to provide a review of available models to assess the impact of possible spills of pollutants. Emphasis was placed on analytical solutions and on assessing the ability to use the models with a minimum of user background. This work was not intended to develop new models, but rather to evaluate existing ones.
(*f*) Completed.
(*g*) A number of analytical models are identified for possible use. The key factor in enabling use by a nonexpert is the inclusion of a maximum amount of advection in the equation and solutions to minimize the effects which must be accounted for by the diffusion coefficients. It is recommended that, at the least, models for rivers include lateral variation of velocity and estuary models include tidal velocity variation.
(*h*) **Review of Toxic Spill Modeling,** B. A. Benedict, Complettion Report. See item b above.
Discussion of **Convective-Dispersion in Perennial Streams, by Anand Prakash,** B. A. Benedict, *J. Environmental Engrg. Div., ASCE* **104**, EE2, pp. 378-380, Apr. 1978.
Analytical Models for Toxic Spills, B. A. Benedict, *Proc. 1978 Natl. Conf. Control of Hazardous Material Spills*, pp. 439-443, Apr. 1978.
Source Condition Influence on Toxic Spill Behavior, B. A. Benedict, *Proc. 1978 ASCE Natl. Conf. Environmental Engrg.*, ASCE, N.Y., pp. 271-278, July 1978.
Effects of Averaging on Solutions to the Convective Diffusion Equation, B. A. Benedict, *Proc. 8th U.S. Natl. Congress of Applied Mechanics*, (Abstract), p. 57.
Effects of Equation Averaging on Model Verification, Verification of Mathematical and Physical Models in Hydraulic Engineering, *Proc. ASCE Specialty Conf.*, pp. 483-491, Aug. 1978.

138-11719-860-26

APPLICATION OF A NEAR-FIELD WATER QUALITY MODEL

(*b*) U.S. Air Force, Air Force Office of Scientific Research, Air Force Systems Command, Bolling AFB, D.C.
(*c*) Dr. Barry A. Benedict, Associate Professor.
(*d*) Theoretical; applied research.
(*e*) This work was intended to further investigate behavior of a previously developed two-dimensional jet integral model describing near-field water quality dynamics and to make recommendations for use of the model and future development.
(*f*) Completed.
(*g*) The model was shown to be a good predictor of behavior when fitted to thermal discharge data. No data on BOD-DO existed for near-field verification. Model limitations include its two-dimensionality, failure to account for boundary impingement, and decreasing accuracy as ambient diffusion becomes more significant. The model can be used to link to several diffusion models, and such linkages are discussed.
(*h*) **Application of a Near-Field Water Quality Model,** B. A. Benedict, Completion Report to AFOSR. See item b.
A Near-Field Model for Dissolved Oxygen and Other Water Quality Parameters, B. A. Benedict, *Proc. 1st Intl. Conf. Mathematical Modeling*, Aug. 1977, St. Louis, Mo.
Modeling Dissolved Oxygen in the Near Field, B. A. Benedict, *Proc. 25th Hydraulics Specialty Conf.*, College Station, Tex., pp. 144-151, Aug. 1977.
Effect of Discharge Mode on BOD and DO, B. A. Benedict, *Proc. ASCE Hydraulics Div. Specialty Conf.*, San Francisco, Calif., Aug. 1979.

138-11720-870-73

DEVELOPMENT OF A SYSTEM OF NEAR-FIELD THERMAL MODELS FOR THE MISSISSIPPI RIVER

(*b*) Middle South Services, Inc., New Orleans, La.
(*c*) Dr. Barry A. Benedict, Associate Professor.
(*d*) Theoretical; applied research.
(*e*) The project was to review available near field models for their applicability to sites in the lower 800 plus miles of the Mississippi for existing or proposed thermal discharges. A justification for selection of a set of these models and a computer package and users manual were to be prepared.
(*g*) Five models were selected and prepared in documented form in a computer package. A surface integral model, finite source diffusion model, and stream tube diffusion model were included, along with models for single and multiport submerged discharges.
(*h*) **Selection of Models to Describe Near-Field Temperature on the Mississippi,** B. A. Benedict. Completion Report.
Users Manual for Middle South Services Near-Field Thermal Discharges Model Systems, B. A. Benedict. Completion Report.

SOUTH DAKOTA STATE UNIVERSITY, Department of Agricultural Engineering, Brookings, S.D. 57007. Professor Dennis L. Moe, Department Head.

139-11074-810-00

NONPARAMETRIC THEORY OF INFILTRATION DURING RAINFALL ON LAYERED SOILS FOR WATER RESOURCES PLANNING

(*c*) Shu-Tung Chu, Assoc. Professor.
(*d*) Theoretical, field investigation; applied research.
(*e*) The recent developments in the analysis of infiltration during variable rain were based upon the Green and Ampt equation. A limitation associated with the Green and Ampt approach is the assumption of a homogeneous soil profile and a uniform soil moisture distribution. Attempts to evaluate the existing analysis by field measurements are

prohibited because under field conditions, the soil is not homogeneous. The purpose of this project is to extend the existing techniques to a layered soil profile and to evaluate the theoretical results by field measurements.

(*g*) Analogy is being established between the Green and Ampt equation and the infiltration capacity curve. By replacing the various forms of the Green and Ampt equation with the associated forms of infiltration capacity curve, the existing analysis is extended to the layered soil profiles. A numerical procedure is developed to model infiltration, during variable rain.

(*h*) **Infiltration During Variable Rain on Layered Soils,** S.-T. Chu, R. A. Young, *Paper No. 79-2041*, Amer. Soc. of Agricultural Engineers.

UNIVERSITY OF SOUTHERN CALIFORNIA, Foundation for Cross-Connection Control and Hydraulic Research, School of Engineering, University Park, Los Angeles, Calif. 90007. Professor E. Kent Springer, Foundation Director.

140-00049-860-73

FOUNDATION FOR CROSS-CONNECTION CONTROL RESEARCH

(*b*) Sustaining membership of Local, State and Federal health and water agencies as well as Provincial health and water agencies in the U.S. and Canada.

(*d*) Experimental laboratory and field investigations; basic and applied research; sponsored and theses (M.S. Engr., and Ph D.).

(*e*) Evaluation of various backflow prevention devices under both laboratory and field conditions. The laboratory contains parallel circuits for all pipe sizes up through 16 inch with capabilities of 4500 gpm at 300 ft head. A parallel system permits the calibration of all normal sizes of water meters. The laboratory is equipped for the training and certification of backflow device testers. This same training and certification program is also available to areas removed from the laboratory by arrangement.

(*g*) Standarized laboratory and field evaluation procedures as well as minimum design and operating specifications have been established for back-flow prevention due to cross-connections. Greatly expanded recognition of the cross-connection control problem by Local, State, Federal and Provincial agencies as well as manufacturers has brought this work of protecting the potable water supply into sharp focus. A major contribution of this program has been the development of the five-day short course and the one-day seminars given both at the Foundation and at agency sites to aid water and health agencies to cope with this cross-connection control problem.

(*h*) **Manual of Cross-Connection Control,** 5th Edition.
Specifications for Back-Flow Prevention Devices, 74.
Cross Talk, a quarterly publication of development news pertaining to cross-connection control.
List of Approved Backflow Prevention Devices. Published several times per year as changes in the "List" occur.

SOUTHERN METHODIST UNIVERSITY, School of Engineering and Applied Science, Department of Civil and Mechanical Engineering, Dallas, Tex. 75275. Dr. Michael A. Collins, Professor.

141-09930-210-33

SOLUTION OF LARGE SCALE PIPE NETWORKS BY IMPROVED MATHEMATICAL APPROACHES

(*b*) Office of Water Research and Technology, United States Department of the Interior.

(*d*) Experimental and theoretical; applied research.

(*e*) Kuhn-Tucker theory is used to show there exist two mathematical programming models whose solution is precisely the solution to the classical pipe network analysis problem. Approximate solutions to this classical hydraulic problem have traditionally been obtained by direct iterative solution of the governing nonlinear network equations. However, one of the mathematical programming models has a special structure well suited to nonlinear optimization techniques. Three optimization algorithms are coded and used to examine the computational efficiency of solving the pipe network analysis problem using the mathematical programming approach. Extension of the theory to open channel networks is also explored.

(*f*) Completed.

(*g*) Three different optimization algorithms are used to solve four pipe network analysis problems. A state of the art Newton-Raphson code is also used to provide a comparison between these three optimization techniques and traditional solution methods. Computational experience with a pipe network of 452 nodes and 530 elements show that solutions with less then 2 percent error are obtained in approximately 50 seconds CPU time on a CDC Cyber 72 computer.

(*h*) **Solving the Pipe Network Analysis Problem Using Optimization Techniques,** M. A. Collins, et. al., *Management Science* **24,** 7, 747-760, Mar. 1978.
Operating Points in Complex Pump Networks, M. A. Collins, et al., *J. Hydraulics Div., ASCE Proc.*, **105,** HY3, 229-244, Mar. 1979.
Discussion of Extended Period Simulation of Water Systems–Part B by Rao, et al., M. A. Collins, et al., *J. Hydraulics Div., ASCE Proc.* **103,** HY12, 1496-1500, 1977.
Analysis of Hydraulic Networks Using Minimization Principles, M. A. Collins, et. al., *Proc. XVIIIth Congress of the Intl. Assoc. Hydraulic Research*, Baden-Baden, Federal Republic of Germany, Aug. 15-19, 1977.
Solution of Large Scale Pipe Networks By Improved Mathematical Approaches, M. A. Collins, et al., *Tech. Completion Rept. IEOR 77016-WR77001*, School Engrg. and Applied Science, Southern Methodist Univ., Dallas, Tex. 75275, 161 pp., Aug. 1978.

141-11075-200-13

SENSITIVITY ANALYSIS OF U.S. CORPS OF ENGINEERS UNSTEADY MODEL INPUT PARAMETERS

(*b*) Vicksburg District, U.S. Army Corps of Engineers.

(*d*) Experimental; applied research.

(*e*) A finite difference model for solving the St. Venant equations for unsteady flow in open channels is to be utilized to numerically evaluate the sensitivity of computed flow parameters to model input parameters. The results of the sensitivity analysis are to be presented so as to be of use to U.S. Corps of Engineers personnel in defining cost effective data collection programs.

SOUTHWEST RESEARCH INSTITUTE, 6220 Culebra Road, P. O. Drawer 28510, San Antonio, Tex. 78284. H. Norman Abramson, Vice President, Engineering Sciences.

142-09300-110-70

STUDIES OF LIQUEFIED NATURAL GAS (LNG) MOTIONS IN PARTIALLY FULL TANKS

(*b*) Methane Tanker Service.

(*c*) Dr. Robert L. Bass, Manager, Hydro-Mechanical Systems.

(*d*) Experimental; applied research.

(*e*) Experimental determination of wave-impact pressures on tank walls.

(*g*) Scale-model studies using liquids with various physical properties, realistic tank geometries, and tank motions were conducted to determine correlating equations for wall pressures in full-scale tanks.

(*h*) SwRI Contractor Reports.

142-09301-620-70

SQUEEZE FILM DAMPERS FOR HIGH-SPEED ROTATING MACHINERY

(*b*) Union Carbide Nuclear Company.
(*c*) Dr. F. T. Dodge, Staff Engineer.
(*d*) Analytical; applied research and development.
(*e*) Analytical investigation of hydrodynamic squeeze film dampers for flexible, high-speed rotors.

142-09304-050-15

CHARACTERISTICS OF HIGH-SPEED COMBUSTING JETS

(*b*) U.S. Army Ballistic Research Laboratory.
(*c*) Dr. F. T. Dodge, Staff Engineer.
(*d*) Theoretical; applied research.
(*e*) Studies of combusting jets issuing from tanks of compressed LPG.
(*g*) Using literature results and original analyses, predictions of the flow characteristics of highly-underexpanded two-phase jets of reacting LPG are being made. The heat transfer to insulated steel plates, placed at various distances from the jet orifice, are computed, with the eventual aim of reducing the "torching" hazard in LPG tank car derailments.
(*h*) SwRI Contractor Reports.

142-09306-640-00

SHOCK PHYSICS AND REACTIVE FLOWS

(*b*) SwRI Internal Research Panel.
(*c*) Dr. R. E. White, Senior Research Engineer.
(*d*) Theoretical; applied research.
(*e*) Explore various techniques of predicting shock or blast-wave interactions with structures or other flow fields.

142-10354-130-70

SCALE MODELING STUDIES OF BWR BLOWDOWN FLUID PHYSICS

(*b*) General Electric Nuclear Energy Systems Division.
(*c*) Dr. F. T. Dodge, Staff Engineer.
(*d*) Experimental and analytical; applied research.
(*e*) Formulate scale-modeling laws and interpret results of tests of massive air/steam injection into water pools.

142-10355-050-50

LIQUID JET IMPINGEMENT ON CLOSELY-WOVEN SCREENS

(*b*) NASA-Lewis Research Center.
(*c*) Dr. F. T. Dodge, Staff Engineer.
(*d*) Analytical; applied research.
(*e*) Develop math model of through-put of incompressible jet impinging on a screen.
(*g*) Good correlation with test data has been achieved; final report is in preparation.
(*h*) **Flow of Liquid Jets Through Closely Woven Screens,** *AIAA J. Spacecraft and Rockets* **15**, Jul.-Aug. 1978, pp. 213-218.

142-10356-650-70

SLOSH DYNAMICS OF OIL PRODUCTION EQUIPMENT

(*b*) AMOCO.
(*c*) Dr. F. T. Dodge, Staff Engineer.
(*d*) Analytical; applied research.
(*e*) Determine susceptibility of conventional 3-phase separators, glycol de-gassers, etc., to performance degradation by slosh effects encountered on flexible off-shore platforms.
(*f*) Completed.
(*g*) Design modifications have been suggested.
(*h*) SwRI Contractor Reports.

142-10357-540-50

FLOW INDUCED VIBRATIONS OF BELLOWS

(*b*) NASA-Marshall Space Flight Center.
(*c*) Mr. J. E. Johnson, Senior Engineer.
(*d*) Analytical; applied research.
(*e*) Extend previous research to cover bellow sizes used in the Space Shuttle.

142-10358-520-45

BULK CARRIER OPERATIONS SAFETY ENHANCEMENT PROJECT

(*b*) U.S. Maritime Administration.
(*c*) Dr. R. L. Bass, Manager, Hydro-Mechanical Systems.
(*d*) Analytical, experimental and field investigation; applied research.
(*e*) An experimental study using scale modeling techniques was conducted to establish improved methods for gas freeing and inerting ship tanks. A test program to confirm the laboratory scale results is underway on a large supertanker.
(*g*) Scale studies established the proper criteria for laboratory scale simulation of ship tank ventilation operations. A parametric study investigated the effects of tank internal structure, inlet/outlet configurations and location, blower flow rate and gas density on the gas exchange process. Comprehensive experiments were performed on six ship tank models that represent extremes in tank geometry for U.S. designed and constructed ships. Design and operational information, and techniques to improve the efficiency of gas exchange processes were developed from the test results.
(*h*) **Phase II Final Report,** issued Oct. 1978.

142-11076-590-48

INVESTIGATION OF HAZARDS POSED BY CHEMICAL VAPORS RELEASED IN MARINE OPERATIONS

(*b*) U.S. Coast Guard.
(*c*) Dr. Robert L. Bass, Manager, Hydro-Mechanical Systems.
(*d*) Analytical, experimental and field investigation; applied research.
(*e*) A background study identified operational procedures that expose dock and ship personnel to chemical vapors. Analytical models were developed to predict the time and spatial vapors on-deck during loading, and the ventilation of cargo tanks prior to man-entry. Vapor concentration measurements were made on two chemical tankerships before and during cargo loading.
(*g*) Good correlation of analytical model predictions and test data has been achieved; final report is in preparation.

142-11077-740-00

DEVELOPMENT OF A GENERALIZED FLUID MECHANICS COMPUTATIONAL CODE

(*b*) SwRI Internal Research Panel.
(*c*) Dr. R. E. White, Senior Research Engineer.
(*d*) Theoretical and experimental; basic research.
(*e*) A finite difference computer code is being developed to predict turbulent recirculating flows with heat and mass transfer and buoyancy effects. Laboratory experiments are being performed to provide data for the validation of computed results.
(*g*) Only preliminary results.

142-11078-290-70

INTERACTION OF PULSATING AND EXPANDING SUBMERGED BUBBLES

(*b*) General Electric Nuclear Energy Systems Division.
(*c*) Dr. F. T. Dodge, Staff Engineer.
(*d*) Analytical and experimental; applied research.
(*e*) Develop math model of the interaction of a submerged pulsating bubble and a submerged bubble whose volume increases continuously; verify model experimentally.
(*f*) Completed.
(*g*) Conditions for resonance to occur have been determined, and loads on nearby structures have been estimated.
(*h*) SwRI Contractor Report; paper is in preparation.

142-11079-590-48

REVISION AND EXPERIMENTAL VERIFICATION OF VENTING RATE MODEL

(*b*) U.S. Coast Guard.
(*c*) Dr. F. T. Dodge, Staff Engineer.
(*d*) Analytical and experimental; applied research.
(*e*) Revise math/computer model which predicts the venting rate of volatile liquids from punctured ship tanks; verify model experimentally.
(*g*) Model has been revised; experimental verification is underway.
(*h*) Interim Report detailing revised model has been issued.

142-11080-520-48

EVALUATION OF LIQUID DYNAMIC LOADS IN SLACK CARGO TANKS (SR-251)

(*b*) Ship Structures Committee/U.S. Coast Guard.
(*c*) Dr. Robert L. Bass, Manager, Hydro-Mechanical Systems.
(*d*) Analytical and experimental; applied research.
(*e*) An evaluation and compilation of currently available sloshing data. Additional experimental studies to establish impulsive pressure waveform characteristics. Analytical efforts to provide slosh load design criteria for LNG ship tanks.

142-11081-030-70

TRANSIENT HYDRODYNAMIC LOADS ON SIMPLE GEOMETRIES

(*b*) General Electric Company.
(*c*) Mr. J. E. Johnson, Senior Engineer.
(*d*) Experimental; applied research.
(*e*) An experimental study was conducted to establish lift and drag loads on I-beams and cylinders positioned transversely to transient flow whose acceleration was in excess of 300 ft/sec^2.
(*f*) Completed.
(*g*) Acceleration drag loads were correlated with analytical model.

142-11082-030-00

INVESTIGATION OF LOADS ON SUBMERGED STRUCTURES CAUSED BY ACCELERATING FLOWS

(*b*) SwRI Internal Research Panel.
(*c*) Mr. J. E. Johnson, Senior Engineer.
(*d*) Experimental; applied research.
(*e*) Extension of previous studies. Flow accelerations will exceed 500 ft/sec^2 in a new facility.

STANFORD UNIVERSITY, Department of Applied Earth Sciences, School of Earth Sciences, Stanford, Calif. 94305. Professor Irwin Remson.

143-08979-810-54

HYDROLOGIC MODELS FOR LAND-USE MANAGEMENT

(*b*) National Science Foundation.
(*c*) Cooperative project with Department of Geology.
(*d*) Theoretical research with field applications; applied research; M.S. and Ph.D. theses.
(*e*) Development of deterministic and optimization computer models of subsurface hydrology for use in studying and managing watershed hydrology.
(*g*) List of papers available on request.

143-10473-820-54

HYDRAULIC AND HYDROLOGIC BEHAVIOR OF INFLUENT STREAMS AND RECHARGE OF UNDERLYING AQUIFERS **(See also Stanford Civil Engineering Department, 144-10409.)**

(*b*) National Science Foundation.
(*c*) Professors Joseph B. Franzini and Irwin Remson (cooperative project with Department of Civil Engineering).
(*d*) Theoretical research with laboratory and field applications; applied research; M.S. and Ph.D. theses.
(*e*) Use of theoretical models and laboratory and field data to study the behavior of influent streams.
(*h*) List of papers available on request.

STANFORD UNIVERSITY, Department of Civil Engineering, Stanford, Calif. 94305. Professor R. L. Street, Department Chairman.

144-10407-010-54

EXPERIMENTAL STUDIES IN THE STRUCTURE OF TURBULENT BOUNDARY LAYER GROWING ON A DEFORMABLE AIR-WATER INTERFACE

(*b*) National Science Foundation.
(*c*) Professor E. Y. Hsu.
(*d*) Experimental; basic research for Doctoral theses.
(*e*) This research project concentrates on defining more precisely the similarities and differences in the structure of turbulence in the boundary layer over rigid and wave-perturbed surfaces.
(*h*) Complete list of reports and papers available on request to correspondent.

144-10409-820-54

HYDRAULIC AND HYDROLOGIC BEHAVIOR OF INFLUENT STREAMS AND RECHARGE OF UNDERLYING AQUIFERS

(*b*) Engineering Division, National Science Foundation.
(*c*) Professor Joseph B. Franzini, Dept. of Civil Engineering, and Professor Irwin Remson, Dept. of Applied Earth Science.
(*d*) Theoretical and experimental; basic research for Doctoral theses.
(*e*) Initially the kinematic wave equation for flow in a very wide channel on a constant slope will be linked numerically to the one-dimensional Richard's equation for unsteady, unsaturated flow in soils. In later work the investigation will be extended to include variation in channel slope, width and depth, variation of the characteristics of the underlying strata, and the effect of lateral spreading of the seepage water.
(*g*) List of papers available on request.

144-10410-860-36

GROUNDWATER RECHARGE BY DIRECT INJECTION OF RECLAIMED WATER

(*b*) EPA, Robert S. Kerr, Environmental Research Laboratory, Ada, Okla.
(*c*) Professor P. L. McCarty, Principal Investigator.
(*d*) Experimental, theoretical and field investigations; basic and applied research; for Doctoral dissertations.
(*e*) To identify processes responsible for water quality changes during groundwater recharge with reclaimed water; to formulate mathematical models to describe the transformations; and to simulate with numerical methods the movement of water and transport of pollutants in the groundwater environment, verifying the models with data acquired in the field.
(*h*) List of reports and publications is available.

144-10411-530-21

FINITE ELEMENT SIMULATION OF THREE-DIMENSIONAL FLOW ABOUT FULLY CAVITATING HYDROFOILS

(*b*) Naval Ship Research and Development Center.
(*c*) Professor R. L. Street.
(*d*) Theoretical, numerical computation, basic research for Doctoral theses.

(e) Develop a numerical finite element computational method for the solution of three-dimensional, irrotational, steady and fully-cavitating flow past arbitrary hydrofoils or other bodies. A fully nonlinear computation method, as is being developed, will have application in the design of hydrofoils and propellors.
(g) Numerical finite element model for fully-cavitating, pure drag flows has been completed and tested. Preliminary lifting flow results have been obtained.

144-10413-140-54

HEAT TRANSFER AT A MOBILE BOUNDARY

(b) Engineering Division (Heat Transfer Program), National Science Foundation.
(c) Professor R. L. Street.
(d) Experimental, numerical and theoretical, basic research for Doctoral theses.
(e) The work is focused on the transport processes occurring at a gas-liquid interface under the action of a turbulent gas flow We seek experimental determination of, and theoretical bases for, the heat transfer in the liquid layer and the partitioning of the sensible and latent heat and mass transfers across the interface under various conditions.
(g) Simple theory for coupled heat, mass and momentum transfer has been developed for turbulent flows on each side of a rough, mobile boundary. Numerical, coupled model for laminar flows also completed.

144-11083-820-33

DEVELOPMENT OF CHEMICAL AND BIOLOGICAL REACTION SUBMODELS FOR USE IN GROUNDWATER TRANSPORT SIMULATION

(b) Office of Water Resources Technology, Department of the Interior.
(c) Professor R. L. Street.
(d) Experimental, numerical, theoretical and field investigation as basic research for Doctoral theses.
(e) Chemical and biological reaction submodels are being developed for reclaimed water transport through porous hydraulic media. Integration of these in groundwater and pollutant transport codes is planned.
(g) Useful results for ion-exchange involving two species with different valences have been obtained.

144-11084-870-55

EVALUATION OF RETENTION AND MIGRATION DATA FROM NATURAL AND INADVERTENT REPOSITORIES–NRC-0478266

(b) Professor Paul Kruger.
(d) Analytical and experimental, applied research.
(e) To prepare a stochastic model of migration of radioactive wastes from data extracted from literature and experimental studies of nuclear materials migration from existing underground repositories.
(g) Progress reports available.

144-11085-060-54

MIXING PROCESSES IN THE SIMULATION MODELING OF IRREGULARLY-SHAPED WATER BODIES

(b) Engineering Division, National Science Foundation.
(c) Professors Joseph B. Franzini, E. Y. Hsu and Robert L. Street.
(d) Theoretical and experimental; basic research for Doctoral theses.
(e) Work is being done in several areas including: 1) Simulation of turbulent stratified flows in large water bodies using finite elements. 2) Analytic investigation of Sub-Grid-Scale turbulence in stratified flows. 3) Laboratory experiments on circulation in stratified rectangular cavities whose upper boundary is subjected to shear stress induced by a moving belt. 4) Experimenal investigation of the effect of vertical distortion on the hydrodynamics of large stratified water bodies using specially designed variable-distortion facility.
(h) Complete list of reports and papers available on request to correspondents.

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ST. ANTHONY FALLS HYDRAULIC LABORATORY, UNIVERSITY OF MINNESOTA, Mississippi River at Third Avenue, S. E., Minneapolis, Minn. 55414. Dr. Roger E. A. Arndt, Director.

Inquiries concerning Projects 08996, 10601 through 10604 and other projects as yet unnumbered should be addressed to Roger E. A. Arndt, Director, St. Anthony Falls Hydraulic Laboratory, Mississippi River at Third Avenue S.E., Minneapolis, Minn. 55414.

Inquiries regarding Projects 00111, 01168, 07677, and 10592 which are conducted by the Science and Education Administration, Agricultural Research (see also project reports from U.S. Government laboratories: U.S. Department of Agriculture, Science and Education Administration, Agricultural Research; North Central Region Project No. 01723) should be addressed to Fred W. Blaisdell, Research Leader, Hydraulics of Structures Research, Science and Education Administration, Agricultural Research, St. Anthony Falls Hydraulic Laboratory, at the above address.

Inquiries concerning Project 00194 should be addressed to John V. Skinner, Engineer in Charge, Federal Inter-Agency Sedimentation Project, St. Anthony Falls Hydraulic Laboratory at the above address.

145-00111-350-05

CLOSED CONDUIT SPILLWAY

(b) Science and Education Administration, Agricultural Research, U.S. Dept. of Agric., in cooperation with the Minnesota Agric. Expt. Sta. and the St. Anthony Falls Hydraulic Laboratory.
(d) Experimental; generalized applied research for development and design.
(e) Recent work has been a model test of a closed tall two-way drop inlet with a crest section twice as long as the drop inlet and a structural transverse wall at the drop inlet midlength. The effect of these deviations from current design standards was determined and modifications suggested. Flow-induced vibrations were also investigated.
(f) Suspended.
(g) The theory of closed conduit spillways has been developed, verified, and published. Results of tests on many forms of the closed conduit spillway entrance have been published. Pipe culverts laid on steep slopes may flow completely full even though the outlet discharges freely. Generalized methods for analysis and reporting of the results have been developed. The use of air as the model fluid has been verified by comparing test results with those obtained using water as the model fluid. The two-way drop inlet with the horizontal anti-vortex device causes the spillway to act as a self-regulating siphon when the headpool level approximates the anti-vortex plate elevation. The height of the anti-vortex plate above the drop inlet crest and the overhang of the anti-vortex plate determine the effectiveness of the plate as an anti-vortex device. For one form of the inlet, tests have been made to determine the crest loss coefficient, the barrel entrance loss coefficient, the pressures on the plate and the drop inlet, the general performance of the inlet, minimum and maximum permissible plate heights, and the head-discharge relationship for plate control. Variables have been the length of the drop inlet, the barrel slope, the height and overhang of the anti-vortex plate, and the sidewall thickness. Tests of low-stage orifices in the two-way drop inlet have shown that improper location and improper proportioning of the orifices can prevent priming of the spillway. The proper location and size of the orifices have been determined. To supplement the experiments, potential flow methods have been used to determine the

theoretical coefficient of energy loss at the crest of the two-way drop inlet. Six shapes of elbow between the two-way drop inlet and the transition were tested. The elbows were evaluated on the basis of high minimum relative pressures and the presence of adverse pressure gradients. The theoretical free streamline elbow had small areas of adverse pressure gradient. The best elbow is an ellipse with semi-major and semi-minor axes of 2D and 1D. (D is the barrel diameter.) An elbow made up to two 45-degree circular segments of radii D/2 and 3D/2 also has generally satisfactory hydraulic characteristics. Seven transitions between the half-square crown, half-circular invert cross section at the elbow exit and the circular barrel were tested. The best transition is warped and 1D long. (See 1968 issue for details,–ed.) The entrance loss coefficients are low and identical within the limits of experimental precision for all elbow-transition combinations. Tests on the hood drop inlet have shown that the hood barrel entrance can be used to reduce the minimum required height of the drop inlet. Minimum sizes of drop inlet and antivortex devices have been determined. Undesirable performance of an operating spillway was traced to air-entraining hydraulic jumps in the barrel, inadequate size and debris-plugged air vents, and delayed venting from under the cover plate skirts that extended below the spillway crest. Adequate venting corrected the undesirable performance. This was achieved by removing a manhole cover in the cover plate. The manhole opening required an antivortex device and a trashrack. The point of termination of the transverse wall near the base of the drop inlet affects the flow in the two drop inlet shafts. Initial designs of the transverse wall resulted in unequal water levels in the two drop inlet shafts prior to priming, and caused submergence of the upstream and downstream crests at different respective stages. To eliminate this effect, the transverse wall should terminate 1D above the beginning of the elbow curvature, or the bottom of the transverse wall should be curved downstream.

(*h*) The following reports are available from the address given in (b) at no cost:

Hydraulic Model Investigation of a Two-Way Drop Inlet for Floodwater Retarding Structure No. 3, Banklick Creek Watershed, Boone and Kenton Counties, Kentucky, *ARS-NC-63*, 20 pages, Aug. 1978

Hydraulics of Closed Conduit Spillways, Part XVI: Elbows and Transitions for the Two-Way Drop Inlet, *AAT-NC-1*, 44 pages, Feb. 1979.

Hydraulics of Closed Conduit Spillways, Part XVII: The Two-Way Drop Inlet With a Semicylindrical Bottom, 28 pages, Apr. 1979.

145-00194-700-10

A STUDY OF METHODS USED IN MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS (Inter-Agency Sedimentation Project in cooperation with St. Anthony Falls Hydraulic Laboratory)

(*b*) Subcommittee on Sedimentation, Interagency Advisory Committee on Water Data; personnel of the U.S. Army Corps of Engrs. and the U.S. Geological Survey are actively engaged on the project.

(*d*) Experimental; applied research and development.

(*e*) Develop equipment and procedures to facilitate both the collection and analysis of sediment transported by natural streams. The project develops sampling equipment to meet special requirements then, as a service to all governmental organizations and to educational institutions, stocks, calibrates, and repairs sampling and analyzing equipment. Major equipment items stocked for resale include a single stage sampler, 4-, 22-, and 62-pound depth integrating samplers, 100-, 200-, and 300-pound electrically operated point-integrating samplers, and an intermittent pumping-type sampler. For the collection of bed material the project stocks piston-type hand operated samplers, 30-, and 100-pound scoop-type samplers. For particle size analysis the project can supply bottom-withdrawal tubes and visual-accumulation sedimentation tubes complete with recorders. The project's long-range objective is to develop an instrument to automatically record the concentration of suspended sediment transported by natural streams. Testing of bed-load samplers is scheduled to begin in 1978.

(*g*) To facilitate field sampling, the project is continuing to design light-weight suspended-sediment samplers that collect large-volume samples for sediment and chemical analysis. As part of a cooperative effort, the project has completed the first phase of experimental study to calibrate six different styles of Helley-Smith bedload samplers. A flume with a cross-section of 9 feet by 6 feet was lined with 6 mm gravel and the samplers were tested at four different transport rates. The maximum rate was 0.6 lb/sec/ft. At all discharges, dunes comprised the dominant bed form. Currently, data is being reduced and preparations are being made for the second test which will be conducted with 2 mm material.

(*h*) **A Study of Methods Used in Measurement and Analysis of Sediment Loads in Streams,** *Report U, An Investigation of a Device for Measuring the Bulk Density of Water-Sediment Mixtures*, J. P. Beverage, J. V. Skinner, 35 pages, Aug. 1974.

A catalog and numerous progress and letter reports are available upon request. Contact the District Engineer, St. Paul District, Corps of Engrs., 1135 U.S. Post Office and Custom House, St. Paul, Minn. 55101.

145-01168-350-05

A STUDY OF CANTILEVERED OUTLETS

(*b*) Science and Education Administration, Agricultural Service, U.S. Dept. of Agric. in cooperation with Minnesota Agric. Expt. Sta. and St. Anthony Falls Hydraulic Laboratory.

(*d*) Experimental; generalized applied research for design.

(*e*) Pipe outlet conduits for small spillways are frequently cantilevered beyond the toe of the earth dam. Attempts are being made to determine quantitatively the size of the scour hole to be expected under various field conditions. Rectangular cantilever outlets with a deflector at the exit to throw the water away from the structure and move the scour hole further downstream are also scheduled for investigation.

(*g*) The shapes of all the holes scoured at the exit of cantilevered pipe outlets have been described mathematically by a single family of ellipses. The equation is valid for all rates of water flow, all lengths of time of scour, all sizes of bed material, and all heights of pipe above or below the downstream water surface. Mathematical modeling of the scour hole parameters continues. The tests are still active.

145-07677-220-05

SCOUR AND PROTECTION AGAINST SCOUR AT STRUCTURES

(*b*) Science and Education Administration, Agricultural Service, U.S. Dept. of Agric., in cooperation with the Minnesota Agric. Expmt. Sta. and the St. Anthony Falls Hydraulic Laboratory.

(*d*) Experimental; generalized applied research for development and design.

(*e*) Laboratory studies to determine for the box inlet drop spillway, the straight drop spillway, and the SAF stilling basin, the size and shape of the scour in sand beds and the size and placement of riprap to protect against scour.

(*f*) Suspended.

145-08996-210-54

THE MECHANICS OF TURBULENCE IN STEADY HELICAL PIPE FLOW

(*b*) National Science Foundation.

(*d*) Experimental, basic.

(*e*) Experimental work was conducted in a 12-inch diameter helical pipe using air as the fluid and hot-film anemometer equipment was used to measure turbulent fluctuations and shear stress in the flow (see g).

(*f*) Completed in so far as possible at this time.

(*g*) Results are reported of experimental measurements of friction factor, mean and turbulent velocities, and Reynolds stresses in fully developed flow through a helically corrugated pipe. The data for turbulence quantities, especially, are new. The helical corrugations induce a strong rotational component in the mean flow near the wall but this decreases rapidly toward the pipe axis. Turbulence intensities and axial shear are generally smaller in this flow than in nonrotating pipe flow and the reduction is attributed to rotation. Reynolds stress measurements extrapolated to the wall are in agreement wiht pressure drop measurements. Both show that pipe friction factor is less in helically corrugated pipe than in normally corrugated pipe, other factors being the same. The axial component of the mean flow is well fitted by the two-dimensional semi-logarithmic law-of-the-wall for rough pipes. It is also fitted by the defect law but the numerical parameters of the latter behave as in an adverse pressure gradient boundary layer, indicating less shear stress (smaller eddy viscosity) than in nonrotating pipe flows. This is consistent with reduced friction factor.

(*h*) **Turbulence in Flow Through Helically Corrugated Pipe,** E. Silberman, submitted to the *J. Fluid Mechanics*.

145-10592-350-05

FLOW-INDUCED VIBRATIONS IN TWO-WAY DROP INLETS

(*b*) Science and Education Administration, Agricultural Research, U.S. Dept. of Agric., in cooperation with the Minnesota Agric. Expmt. Sta. and the St. Anthony Falls Hydraulic Laboratory.

(*d*) Experimental; basic and generalized applied research for development and design.

(*e*) Determine if fluctuating hydrodynamic forces generated by flows in two-way drop inlets are sufficiently intense to cause destructive structural vibration or if they merely produce acoustical noise. Develop a generalized analytical model and computer program for qualitatively and quantitatively predicting the vibration of models or prototypes. Develop means of minimizing or eliminating objectionable pulsating forces and/or flow-generated noise in these structures.

145-10601-350-75

GURI PROJECT FINAL PHASE: HYDRAULIC MODEL FABRICATION

(*b*) Harza Engineering Company.

(*d*) Design and construction.

(*e*) Provide expertise in the form of assistance and supervision of local personnel in the construction of the Guri model (Venezuela) involving machine ship work; steel fabrications and piping work; carpentry work; and concrete and masonry work.

(*f*) Work being done by St. Anthony Falls Hydraulic Laboratory is completed.

(*g*) Work on project is still underway.

145-10602-870-75

RECIRCULATING CONDENSER WATER FOR A COOLING TOWER

(*b*) Sverdrup and Parcel and Associates.

(*d*) Experimental; design.

(*e*) The collecting basin beneath a circular plan form, natural draft cooling tower will also be used as a storage basin for cooling water. An investigation was made of the relationship between water depth in the basin and in the pump bay as influenced by connecting channel design for given tower support pedestals (some of which must stand in the basin outlet) and pumping rates.

(*f*) Complete.

(*g*) Channel configuration and pedestal streamlining are being designed to meet storage and pumping criteria.

(*h*) **Hydraulic Model Studies For A Cooling Tower Circulating Water System, Callaway Plant Unit–Union Electric Company,** E. Silberman, W. Q. Dahlin, *St. Anthony Falls Hydraulic Lab. Project Rept. 167*, Apr. 1977.

Hydraulic Model Studies of the Intake Water Pump Bays for the Callaway County Nuclear Power Plant, J. F. Ripken, K. J. Anderson, *St. Anthony Falls Hydraulic Lab. Ext. Memo No. 140*, Jan. 1977.

145-10603-390-75

TRANSIENT ANALYSIS STUDY OF THE CULVER-GOODMAN TUNNEL

(*b*) Lozier Engineers.

(*d*) Theoretical, applied research.

(*e*) Construct a mathematical model of the Culver-Goodman and Cross-Irondequoit Tunnels, Rochester, N.Y., flow system and run it for various operating conditions.

(*g*) The transient two-phase flow model developed for the Culver-Goodman Tunnel is being expanded and applied to a larger system including Cross-Irondequoit Tunnel. The model is being used for the purpose of optimum design and control of the system.

(*h*) **Hydraulic Transient Analysis for the Culver-Goodman Tunnel, Rochester, New York,** C. S. Song, T. M. Ring, A. C. H. Young, K. S. G. Leung, *St. Anthony Falls Hydraulic Lab. Project Rept. No. 157*, Dec. 1975.

Two-Phase Flow Hydraulic Transient Model for Storm Sewer Systems, C. S. Song, *2nd Intl. Conf. Pressure Surges*, London, Sept. 1976.

Interfacial Boundary Condition in Transient Flows, C. C. S. Song, *Advances in Civil Engrg. Through Engrg. Mechanics, 2nd Ann. Conf., Engrg. Mech. Div., ASCE*, May 1977.

Verification of Transient Mixed-Flow Model, C. C. S. Song, *ASCE 26th Ann. Hydraulic Div. Specialty Conf.,* College Park, Md., Aug. 1978.

145-10604-860-36

WATER TEMPERATURE STUDIES AT THE MONTICELLO FIELD STATION

(*b*) Environmental Protection Agency.

(*d*) Project involves field measurements, theoretical analysis, and development of a numerical model for temperature prediction in a narrow channel.

(*e*) Study conducted to provide information on the temperature characteristics encountered in the Monticello Field Channels. The channels are used for ecological experiments.

(*g*) A numerical model for water temperature distribution in the MFS channels has been developed. Convective and evaporative heat transfer through the water surface, as well as longitudinal dispersion were studied. A wind speed function and a longitudinal dispersion value were derived by analysis of weather and water temperature and weather data.

(*h*) **Operational Water Temperature Characteristics in Channel No. 1 of the USEPA Monticello Ecological Research Station,** H. Stefan, M. Hahn, J. Gulliver, *St. Anthony Falls Hydraulic Lab. Ext. Memo 151*, Jan. 1978.

Physical Characteristics of the Experimental Field Channels at the USEPA Ecological Research Station, in Monticello, Minnesota, H. Stefan, J. Gulliver, M. Hahn, *St. Anthony Falls Hydraulic Lab. Ext. Memo 156*, Apr. 1978.

145-11086-340-75

HYDRAULIC MODEL STUDIES OF THE CULVER-GOODMAN TUNNEL EXIT CONDUIT

(*b*) Harza Engineering Company and Lozier Engineers, Inc.

(*d*) Experimental; applied research.

(*e*) The model consisted of the dropshaft, exit conduit to the storage tunnel and a section of the tunnel. Hydraulic characteristics were investigated with the inlet pipe in line with the sump and exit conduit and turned 30 degrees, and exit conduit slopes of 12.5 and 25 percent. Particular attention was focused on air entrainment in the upper elbow and vertical dropshaft, energy dissipation and air release in the sump at the bottom of the dropshaft, air venting back to the ground surface, and flow conditions in the exit conduit and storage tunnel.

145-11087-340-75

HYDRAULIC MODEL STUDIES OF THE CULVER-GOODMAN CONTROL STRUCTURE

(*b*) Harza Engineering Company and Lozier Engineers, Inc.
(*d*) Experimental; applied research.
(*e*) The model of the diversion structure consists of an inlet tunnel and upper distribution chamber with an overflow weir and sluices leading to a lower drop chamber and exit tunnel. Low flows are diverted through the sluices to the drop chamber. As the inflow increases, the sluices are used to limit the flow into the drop chamber with the excess going over the weir in the distribution chamber. Flow conditions are being investigated in the distribution chamber, sluices, and drop chamber with emphasis focused on vorticity, air entrainment and release, and amount of air entering the exit conduit.

145-11088-160-75

TESTS OF SOUND SUPPRESSION WATER SYSTEMS

(*b*) Reynolds, Smith and Hills Architects-Engrs-Planners (NASA subcontract).
(*d*) Experimental, applied research.
(*e*) For the purpose of noise suppression, NASA space shuttle launchings will require delivery of 200,000 gals. of water in 20 seconds from an elevated storage tank to a spray nozzle system surrounding the rocket engines. Previous model studies were made of a bellmouth outlet of the bottom of the tank. A change in the flow requirements necessitated a reevaluation of the recommended outlet. A 1 to 11.4 model of the tank and part of the flow system was studied, and a different outlet shape was selected and tested for hydraulic performance.
(*f*) Completed.
(*g*) A rounded outlet lip with a radius of about 0.12 times the diameter of the outlet pipe provided a flow free of visible vorticity and cavitation choking. The stage-time curve during falling head was essentially the same as for the previously tested bellmouth, except that the flow time for sound suppression was increased by about 66 seconds due to the increased water volume available with the outlet lip at a lower elevation.
(*h*) **Model Studies of a Revised Outlet for the Elevated Water Tank of a Sound Suppression Water System,** J. Wetzel, J. Ferguson, J. Ripken, *St. Anthony Falls Hydraulic Lab. External Memo 160*, Nov. 1978.

145-11089-720-30

CONSTRUCTION OF A BEDLOAD SAMPLER CALIBRATION FACILITY

(*b*) U.S. Geological Survey.
(*d*) Experimental; design.
(*e*) Construct a flume in the St. Anthony Falls Hydraulic Laboratory for the purpose of testing bedload samplers.
(*f*) Completed.
(*g*) A facility was constructed to permit calibration of full scale bedload samplers with coarse bed materials. The existing 9 ft wide main channel of the Laboratory was fitted with sediment traps, a system for continuously measuring the rate of bedload transport, and a sediment recirculating system. The facility is capable of handling sediment with D_{50} of up to 64 mm and transport rates of up to 5 lb/ft-sec. Tests are being conducted by USGS personnel.

145-11090-350-75

HYDRAULIC MODEL STUDIES OF SAN LORENZO SPILLWAY

(*b*) Harza Engineering Co.
(*d*) Experimental; applied.
(*e*) The San Lorenzo project is located in El Salvador about 50 kilometers upstream of the mouth of the Lempa River. It includes construction of a 46 m high dam, a 180 MW powerhouse, and a 25,000 cms capacity spillway. The objective of the model studies was to observe the hydraulic characteristics of the flow in the approach, the spillway, and the tailrace. Two undistorted, Froude scaled models with a movable bed tailrace were constructed. A 1:50 scale section model consisting of two spillway bays was used to evaluate stilling basin elevations, and a 1:100 scale comprehensive model was used to observe overall flow characteristics of the structure.
(*f*) Completed.
(*g*) A satisfactory stilling basin configuration was established in the section model, and data were collected to determine spillway rating curves, water surface profiles, static and transient pressures on the spillway and in the stilling basin, and erosion patterns in the tailrace. The comprehensive model confirmed the overall design.
(*h*) **Model Studies of the San Lorenzo Spillway Executive Hydroelectric Commission, Lempa River, El Salvador, Central America,** J. M. Wetzel, W. O. Dahlin, *St. Anthony Falls Hydraulic Lab. Project Rept. No. 173,* June 1978.

145-11091-250-21

EFFECT OF DRAG REDUCING POLYMER ADDITIVES ON SURFACE-PRESSURE-FLUCTUATIONS ON BODIES OF REVOLUTION WITH ROUGH SURFACE MOVING THROUGH WATER

(*b*) Naval Ship Research and Development Center.
(*d*) Experimental; basic.
(*e*) Assess the magnitude of the surface pressure fluctuations on a body moving in water and in water with polymer additive under nearly zero pressure gradient conditions. Measurements were made using a single transducer in the surface of an axisymmetric body. The body rose by buoyancy in a standpipe filled with water or water and polymer additive; the standpipe diameter is 5 times the body diameter and its length is 120 body diameters. Both smooth and grit-roughened body surfaces were used.
(*f*) Completed in so far as funds permitted.
(*g*) Mean square pressure fluctuation amplitudes were measured as a function of frequency, nondimensionalized, plotted, and compared with some results obtained by others in both water and air. It was found that the addition of roughness to a smooth surface increases the amplitude at the peak of the spectrum and at all lower frequencies. Polymer additive in the water has just the opposite effect on a rough-surfaced body, decreasing the amplitude at the peak and at all lower frequencies, the reduction increasing monotonically with drag reduction. There was little or no effect at high frequencies attributable to either roughness or polymer additive, but it must be noted that the transducer used was too large to obtain a true measure of amplitude at the highest frequencies. The peak of the spectrum in water appears to have a somewhat higher amplitude than it does in air.
(*h*) **An Experimental Investigation of the Effect of Drag Reducing Polymer Additives on Surface Pressure Fluctuations on Bodies of Revolution with Rough Surfaces Moving Through Water,** E. Silberman, *St. Anthony Falls Hydraulic Lab. Project Rept. No. 172,* May 1978.

145-11092-340-73

HYDRAULIC MODEL STUDIES OF A CIRCULATING WATER SYSTEM FOR SHERBURNE COUNTY GENERATING PLANTS–UNITS 3 AND 4

(*b*) Northern States Power Company and Black and Veatch Engineers.
(*d*) Experimental.
(*e*) A new form of bypass for routing circulating cooling water around a cooling tower during cold start-up had been designed for the proposed power plant. Questions existed with regard to the effectiveness of energy dissipation in the by-pass and the resulting stability of flow. A new design of pump sump had been proposed for the two 5,000 HP pumps used to recirculate the cooling water. Questions existed on the quality of flow entering the pump suction from the sump. Symmetry and uniformity of velocity were examined together with the presence of vortices.
(*f*) Completed.

(*g*) Minor revisions were made in the cold water by-pass unit but the proposed pump sump proved adequate without revisions.

(*h*) **Hydraulic Model Studies of the Circulating Water System for the Sherburne County Generating Plant–Units 3 and 4**, J. F. Ripken, T. Mendell, *St. Anthony Falls Hydraulic Lab. Project Rept. No. 169*, Jan. 1978.

145-11093-300-88

CONFLUENCE OF MISSISSIPPI AND CHIPPEWA RIVERS, PHYSICAL MODELING

(*b*) Great River Environmental Action Team.

(*d*) Experimental; applied research.

(*e*) Chippewa River carries a large quantity of sediment into the Mississippi River. This sediment deposits at the confluence and forms a delta. The sediment in the delta is carried further downstream and deposited in the Mississippi River during the spring flood period. This is why dredging is required almost every year to keep the river open for traffic. This research project is part of the GREAT study effort to find means to reduce the dredging requirement.

(*g*) The physical model has been constructed and calibrated. The model fairly well simulated the events in 1977-1978. Several experimental runs were also made to provide data for the calibration of mathematical model being developed separately. Other runs were also conducted to study the sediment transport mechanism.

(*h*) Report in preparation.

145-11094-300-34

ANNUAL ALLOTMENT PROGRAM–A STUDY OF LOW FLOW WATER CIRCULATION IN THE MISSISSIPPI RIVER DOWNSTREAM FROM ST. PAUL

(*b*) U.S. Department of the Interior.

(*d*) Analytical (numerical) study, with some basic and some applied features; for Ph.D. thesis.

(*e*) A comprehensive computational model for the water circulation and mass transport in Pool No. 2 of the Mississippi River (downstream from Minneapolis-St. Paul) under low flow conditions, including effects of wind is being developed.

(*g*) Preliminary results show that the circulation under low flow is highly variable in time and that the mass transport part of the model matches field (dye) observations well. The sensitivity of the model to various input parameters is being investigated.

(*h*) Report in preparation.

145-11095-870-75

MATHEMATICAL MODEL STUDIES OF IRONDEQUOIT TUNNEL–PUMP STATION–CULVER-GOODMAN TUNNEL SYSTEM FOR INSTRUMENTATION AND CONTROL

(*b*) O'Brien and Gere Engineers.

(*d*) Theoretical; applied research.

(*e*) The transient mixed-flow model developed for Lozier Engineers is being used to study the hydraulic characteristics and the optimum control method for athe Cross-Irondequoit Tunnel and the pumping station of the sewer system in Rochester, N.Y.

(*g*) It appears possible to store substantial amounts of storm water in the main sewer lines for later treatment by properly controlling the inflow and outflow from the system.

145-11096-340-70

ANALYTICAL AND HYDRAULIC MODEL STUDIES OF THE COOLING WATER INTAKE SYSTEM FOR THE CONSUMER POWER COMPANY'S JAMES H. CAMPBELL PLANT UNIT NO. 3

(*b*) Johnson Division of UOP, Inc.

(*d*) Mostly experimental study of novel cooling water intake design. Some computer simulations; a design oriented applied research project.

(*e*) A cooling water intake system consisting of a very large number of cylindrical screens has been investigated. The system operates at unusually low withdrawal velocities to avoid fish impingement and uses small screen openings to reduce entrainment. Studies of single and multiple screens were conducted to determine internal and external flow fields, to measure headloss characteristics, and to achieve balanced withdrawal. Six different physical models were used to study (a) screens, (b) individual intake risers, (c) multiple intake risers, (d) manifold intake headers, (e) collector well structure, and (f) valve.

(*g*) The results of the study are described in the reports listed below. Hydraulic characteristics of several elements of the system were established and related to overall system performance.

(*h*) **Headloss Characteristics of Six Profile-Wire Screen Panels**, H. Stefan and A. Fu, *St. Anthony Falls Hydraulic Lab. Project Rept. No. 175*, Sept. 1978.
Collector Well Study for the Cooling Water Intake System of the James H. Campbell Electric Power Generating Plant, Unit No. 3, H. Stefan, A. Fu, *St. Anthony Falls Hydraulic Lab. Project Rept. No. 176*, Nov. 1978.
Experimental Studies of Cylindrical, Fully-Submerged Water Intake Screens for the James H. Campbell Electric Power Generating Plant, Unit No. 3, H. Stefan, W. Dahlin, J. Ripken, A. Wood, T. Winterstein, *St. Anthony Falls Hydraulic Lab. Project Rept. No. 177*, Dec. 1978.
Cooling Water Intake Manifold (Header) Study for the James H. Campbell Electric Power Generating Plant, Unit No. 3, H. Stefan, C. Shanmugham, S. Dhamotharan, *St. Anthony Falls Hydraulic Lab. Project Rept. No. 178*, Jan. 1979.
Mathematical Study of a Cooling Water Intake for the James H. Campbell Electric Power Generating Plant, Unit No. 3, J. Killen, H. Stefan, *St. Anthony Falls Hydraulic Laboratory External Memo. No. 161*, Dec. 1978.
Motion picture (color, silent), **Laboratory Studies of the James H. Campbell Cooling Water Intake.**

145-11097-870-75

MATHEMATICAL AND HYDRAULIC MODEL STUDIES

(*b*) Black and Veatch Engineers.

(*d*) Theoretical; applied research with some field measurement.

(*e*) A transient mixed-flow model is being developed for the purpose of analyzing the hydraulic characteristics of the sewer system in St. Louis. Data concerning the physical dimensions, rainfall, and depth of flow were taken in the field. These data were used for the development and calibration of the model.

145-11098-340-75

MODEL STUDIES, CLAY BOSWELL PLANT INTAKE, MINNESOTA POWER AND LIGHT

(*b*) Ebasco Services, Inc.

(*d*) Experimental; applied.

(*e*) An existing stream electric power plant was to be expanded by the addition of another generating unit. The existing cooling water intake was to be modified by the replacement of existing makeup water pumps with pumps of larger capacity, which are placed in a sump of complex form. It was expected that the new pumps might experience adverse suction side flows and might in turn produce adverse suction effects in existing large circulating water pumps. Hydraulic model studies of the sump-pump arrangement were carried out at a 1:8.4 scale to establish the presence of any adverse flows and to determine corrective measures.

(*f*) Completed.

(*g*) Tests under low water conditions and with both Froude and near-full scale velocities revealed no air sucking or serious votexing problems at the pump suction. Changes in the vertical and horizontal position of the new makeup water pumps in the sump were recommended together

with the addition of an upstream vertical screen to correct upstream flow disturbance and to homogenize the downstream turbulence structure.

(*h*) **Hydraulic Model Studies for Modifications of the Cooling Water Intake for Unit No. 4–Clay Boswell Plant of the Minnesota Power and Light Company,** J. Wetzel, J. Ripken, *St. Anthony Falls Hydraulic Lab. Project Rept. No. 171*, Apr. 1978.

145-11099-860-36

STUDY OF OXYGEN PRODUCTION, LOSS, EXCHANGE, AND TRANSPORT RATE IN MERS FIELD CHANNELS

(*b*) Environmental Protection Agency.

(*d*) Field and analytical study; computer simulation; thesis project.

(*e*) The diurnal oxygen cycles in a 500 m long experimental field channel are measured and analyzed to establish plant community photosynthesis and respiration rates. Oxygen transport models of differing degrees of sophistication are being applied. The oxygen dynamics will be used by other investigators to determine the response of plant communities to various toxic materials.

(*g*) Graphical methods and a computer model have been developed to route oxygen through the system. The usefulness of the models is being evaluated.

(*h*) In preparation.

145-11100-870-75

HYDRAULIC MODEL STUDIES OF THE VAN LARE OVERFLOW TREATMENT FACILITIES

(*b*) O'Brien and Gere Engineering and Pure Water District, Monroe County, N.Y.

(*d*) Experimental; applied.

(*e*) A physical model of the flow distribution structure designed for Rochester, N.Y. was constructed and tested.

(*f*) Completed.

(*g*) The designed structure performed satisfactorily.

(*h*) **Model Study of the Van Lare Overflow Distribution Structure,** C. S. Song, J. M. Killen, *St. Anthony Falls Hydraulic Lab. Project Rept. No. 174*, July 1978.

145-11101-050-26

INVESTIGATION OF COHERENT STRUCTURE IN THE ACOUSTIC FIELD OF LOW REYNOLDS NUMBER JETS

(*b*) Air Force Office of Scientific Research.

(*d*) Experimental; basic research; Ph.D. thesis.

(*e*) This is a phase of a cooperative program with Professor W. K. George at SUNY-Buffalo and Professor H. Nagib at ITT. The objective is to determine whether or not there is a relationship between sound radiation and coherent structure in jet turbulence. Experiments are carried out at low Reynolds number where orderly structure has been observed in the past. Measurements of the acoustic field will be compared with theoretical estimates of the acoustic radiation from the large eddy structure as deduced from turbulence measurements using the Lumley orthogonal decomposition scheme. Flow visualization, using special techniques, is used to establish a relationship between orderly deduced in the measurement program and that deduced in a more qualitative manner. (Does what we see really exist?)

(*g*) A special aeroacoustic test facility has been designed and constructed. Special emphasis has been placed on properly modeling the entrainment flow and allowing for recirculation through the test facility. Development of a specialized data reduction system capable of handling multi-channel information at 100 kHz is 50 percent completed.

(*h*) **Peak Strouhal Frequency of Subsonic Jet Noise as a Function of Reynolds Number,** K. Yamamoto, R. Arndt, submitted for publication in the AIAA Journal.
Asymmetry of a Circular Jet Observed in Near and Far Fields, K. Yamamoto, R. Arndt, submitted for publication in the AIAA Journal.

145-11102-030-54

MEAN AND FLUCTUATING PRESSURE DISTRIBUTION ON CIRCULAR CYLINDER WITH LARGE ROUGHNESS

(*b*) National Science Foundation.

(*d*) Experimental and analytical; basic research; M.S. and Ph.D. theses.

(*e*) Project seeks to extend work done under a previous NSF Grant on the problem of wind loading or circular cylinders and by parabolic cooling towers, with particular emphasis on flows around circular cylinders because of their relative simplicity and fundamental importance. Specifically, the project seeks to: 1) Extend the theoretical understanding of the flow phenomena and obtain quantitative results using up-to-date boundary layer calculation procedures, and develop an interaction model to couple the boundary-layer and wake behavior with the external potential flow. 2) Make additional measurements on the boundary layer on a circular cylinder with large roughness and study the fluctuating wind loads on models with rough surfaces.

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STEVENS INSTITUTE OF TECHNOLOGY, Davidson Laboratory, Castle Point Station, Hoboken, N. J. 07030. Dr. John P. Breslin, Director.

146-08980-520-21

ADDED MASS AND DAMPING OF THE HEAVING SURFACE-EFFECT SHIP IN UNIFORM TRANSLATION

(*b*) David W. Taylor Naval Ship Research and Development Center.

(*c*) Dr. C. H. Kim and Dr. S. Tsakonas, Chief, Fluid Dynamics Division.

(*d*) Theoretical; applied.

(*e*) The analysis is directed at the problem of finding the effect of the presence of the water wave upon the bubble (or cushion) pressure in the plenum of a surface-effect ship as it is forced in simple harmonic heaving motion while translating at constant speed over an otherwise calm water.

(*f*) Completed.

(*g*) The analysis presents a practical method for evaluating the added mass and damping coefficients of a heaving surface-effect ship in uniform translation. The theoretical added mass and damping coefficients and the heave response show fair agreement with the corresponding experimental values. Comparisons of the coupled aerohydrodynamic and uncoupled analytical results with experimental data prove the uncoupled theory, dominant for a long time, that neglects the free surface is an oversimplified procedure. The analysis also provides means of estimating the wave elevation of the free surface, escape area at the stern and the volume induced by a heaving air-cushion vehicle in uniform translation.

(*h*) **Added Mass and Damping of the Heaving Surface-Effect Ship in Uniform Translation,** C. H. Kim, S. Tsakonas, *Davidson Lab. Rept. SIT-DL-78-9-2040*.
Waves Generated by a Uniformly Moving Oscillatory Surface-Effect Ship, *Davidson Lab. Letter Rept. 1874*.

146-10036-550-21

MODIFICATION OF THEORY FOR PROPELLER STEADY AND UNSTEADY LOADING TO ACCOUNT FOR SHIP WAKE AND MEAN PROPELLER LOADING

(*b*) David W. Taylor Naval Ship Research and Development Center.

(*c*) Dr. S. Tsakonas, Dr. J. P. Breslin and Ms. W. R. Jacobs.

(*d*) Theoretical; applied.

(*e*) To modify the existing analysis and corresponding program for the evaluation of the propeller steady and unsteady loading and resultant hydrodyanmic forces to account for the ship mean wake and mean propeller induction.

(*f*) Completed; report in preparation.

(*g*) Analysis is based on an iterative procedure which, in addition to taking into account the ship wake and propeller induction, incorporates the nonlinear kinematic and dynamic conditions existing on the blade. Thus a theory has been developed which is valid for a moderately loaded propeller. Numerical results for a heavily loaded propeller show good agreeement with experiments under the same conditions.

(*h*) **Analysis of Moderately Loaded Propeller**, *Davidson Lab. Rept. 2063*, in preparation.

146-10037-630-21

A THEORY AND COMPUTER PROGRAM FOR VIBRATORY FORCES OF PUMP-JETS

(*b*) David W. Taylor Naval Ship Research and Development Center.
(*c*) Dr. S. Tsakonas, Ms. W. R. Jacobs and Mr. P. Liao.
(*d*) Theoretical; applied.
(*e*) To develop a theory and corresponding program for the evaluation of the steady and time-dependent loading distribution on all lifting surfaces of a pump-jet propulsive unit and the corresponding hydrodynamic forces and moments exerted on the system. The kinematic boundary conditions which exist on both lifting surfaces (propeller and rudder) lead to a pair of integral equations whose kernels have high order singularity of "Hadamarad" type.

151-10038-520-45

PROPELLER-INDUCED VIBRATORY HULL FORCES

(*b*) Office of Maritime Technology–Maritime Administration.
(*c*) Mr. D. Valentine and Dr. S. Tsakonas.
(*d*) Theoretical; applied.
(*e*) Develop a theoretical approach and corresponding computer program to evaluate the propeller-induced vibratory forces on a hull. The Hess-Smith program (of McDonnell-Douglas Co.) is utilized in conjunction with the propeller-induced velocity field program (Davidson Laboratory of SIT) to evaluate the source strengths representing the hull in the presence of the propeller. Then by application of the extended Lagally Theorem, the hydrodynamic forces and moments are determined.
(*f*) Completed.
(*g*) The vertical component of the hull forces compared very well with the experiments.
(*h*) **Theoretical Procedure for Calculating the Propeller-Induced Hull Forces,** *Davidson Lab. Rept. SIT-DL-78-1979*, (in preparation).

146-10039-420-54

WAVE AND HORIZONTAL SHEAR FLOW INTERACTION

(*b*) National Science Foundation–Engineering Division.
(*c*) Professor T. V. Davies, Dr. S. Tsakonas, Dr. C. H. Kim and H. T. Chen.
(*d*) Theoretical; applied.
(*e*) Develop a theory for treating the interaction of deep-water gravity waves with horizontal shear flow (current) beyond the transient flow domain of the initial interaction between wave system and current. A simplified mathematical model is introduced based on the following assumptions: i) current distortion during the interaction is ignored, ii) the wave length or wave number remains constant. The analysis leads to an integral equation for the unknown amplitude of the resulting surface pressure distribution, the solution ofwhich is obtained by means of Fourier integral transforms.
(*f*) Completed.
(*g*) Systematic caluclations performed for a variety of current distributions reveal the importance of the symmetry and shape of the distribution, the width of the back-flow domain as well as the wave length in "quieting down" (i.e., attenuating) the resulting flow field after the wave-current interaction.
(*h*) **Wave and Shear Flow Interaction,** *Davidson Lab. Rept. SIT-DL-78-1980*, Apr. 1978.

146-11103-550-21

BLADE LOADING DISTRIBUTION ON PROPELLERS OPERATING IN INCLINED INFLOWS

(*b*) David W. Taylor Naval Ship Research and Development Center.
(*c*) Mr. Daniel T. Valentine and Dr. S. Tsakonas.
(*d*) Theoretical; applied.
(*e*) Develop a theory and computational procedure for evaluating the blade loading distribution on a propeller operating in a nonuniform, inclined inflow, the calculations to be compared with existing experimental data. The theory is an extension of the existing unsteady lifting surface theory developed for an axial inflow and takes into account the effect of the distortions of the helicoidal sheets shed by the propeller in an inclined flow. The theory is for lightly loaded propellers. The theoretical procedure was coded in FORTRAN to be run on a CDC 6600 computer.
(*f*) Completed.
(*g*) The effect of flow inclination on the blade bending moments is demonstrated to be significant. The across-the-disk component of the oncoming flow is the primary contributior to the shaft frequency harmonic of the blade bending moment. The effect, however, of the helical wake distortion due to shaft inclination adds very little to the amplitude of the shaft frequency blade bending moment. This is because it is about 90 degrees out of phase with the primary contributor. This result is shown to be plausible on physical grounds. The inclined shaft analysis results in an integral equation which relates the first shaft frequency loading with those of zero (time average) and second blade frequencies.
(*h*) **Linearized Unsteady Lifting Surface Theory of a Lightly Loaded Propeller in an Inclined Flow,** D. T. Valentine, *Davidson Lab. Rept. SIT-DL-79-2064*, in preparation.

146-11104-550-21

VERIFICATION AND PARAMETRIC EVALUATION OF A COMPUTER PROGRAM FOR PROPELLER-INDUCED HULL PRESSURES AND FORCES

(*b*) David W. Taylor Naval Ship Research and Development Center.
(*c*) Dr. S. Tsakonas, Mr. P. Liao and Ms. W. R. Jacobs.
(*d*) Theoretical; applied.
(*e*) Establish a reliable procedure for prediction of the mean and blade-frequency pressures induced by a ship propeller on any point of an arbitrary hull form in the presence of a free surface, then to determine the hydrodynamic forces at zero and blade frequency. The verification of the program will be established by a comparison with an extensive set of measurements made in Norway. The program with the McDonnell-Douglas program modified to accept the velocity potential function for the propeller-induced effects instead of the corresponding velocity field. The effect of the free surface will be taken into account by considering a double body (the hull and its reflection) and propeller in a fully submerged state.

146-11105-520-22

FORCE AND MOMENT CHARACTERISTICS OF A SURFACE-EFFECT SHIP (SES)

(*b*) Surface Effect Ships Project Office.
(*c*) Mr. Gerard Fridsma, Chief, Marine Craft Dynamics Division.
(*d*) Experimental; applied research.
(*e*) Calm water, constant speed tests were conducted on a SES model whose seals and sidewalls were separately isolated from the SES structure so as to measure the forces and mmoments developed on these component parts. Runs were made free-to-heave and either free-to-trim or fixed trim. Three bow seal configurations were tested; parameters were speed, displacement, LCG position, seal stop height and air flow rate.
(*f*) Completed.

(*h*) **The Contribution of Seals and Sidewalls to the Force and Moment Characteristics of a SES,** R. Van Dyck, G. Fridsma, *Davidson Lab. Rept. SIT-DL-79-1861*, Apr. 1979.

146-11106-520-21

ANALYTICAL INVESTIGATION OF THE QUADRATIC FREQUENCY RESPONSE FOR LATERAL DRIFTING FORCE AND MOMENT

(*b*) David W. Taylor Naval Ship Research and Development Center.
(*c*) Dr. C. H. Kim and Mr. J. F. Dalzell.
(*d*) Analytical; applied.
(*e*) Develop and verify a method for computation of the quadratic frequency response function for the lateral drifting force and moment.
(*g*) A near-field method has been developed for calculating the second-order lateral drifting force and moment. Analytical and experimental estimates of the mean drifting force were found to be in good agreement. The quadratic frequency response function and the slowly varying drifting force and moment will be computed in the time domain.

146-11107-550-21

PROPELLER-RUDDER INTERACTION WITH TRANSVERSE PROPELLER-RUDDER CLEARANCE

(*b*) David W. Taylor Naval Ship Research and Development Center.
(*c*) Dr. S. Tsakonas, Ms. W. R. Jacobs and Mr. P. Liao.
(*d*) Theoretical; applied.
(*e*) The existing analysis and program for the propeller-rudder interaction has been updated incorporating all the improvements concerned with the propeller loading distribution, including that associated with the fact that the rudder is immersed in the race of the propeller. The analysis and corresponding computer program will be extended to incorporate transverse propeller-rudder clearance. This new propeller-rudder arrangement facilitates considerable removal of the propeller shaft for repairs without the need to "unship" the rudder.

146-11108-550-21

EFFECT OF RADIAL SHEAR ON THE EFFECTIVE WAKE INTO THE PROPELLER OF FULLY SUBMERGED BODIES

(*b*) David W. Taylor Naval Ship Research and Development Center.
(*c*) Mr. Daniel T. Valentine, Research Engineer, and Dr. T. R. Goodman, Senior Research Scientist.
(*d*) Theoretical; applied.
(*e*) Develop a propeller theory to compute the propeller-induced velocity field, taking into account in a rational way, the effect of a frictional wake impinging on the propeller such as actually occurs behind a submarine. The effect of the propeller-induced velocity field on the flow around the hull will be determined by computing the velocity profile just ahead of the propeller. It is expected that the importance, if any, of the effect of the shear in the propeller inflow on its radial distribution of loading can be assessed from the results.

TEXAS A&M UNIVERSITY, Department of Civil Engineering, College Station, Tex. 77843. Dr. John B. Herbich, Professor and Head, Coastal, Hydraulic and Ocean Engineering Group.

147-09047-420-13

EFFECTS OF CURRENT ON CHARACTERISTICS OF GRAVITY WAVES

(*b*) Texas A&M University and U.S. Army Engineers Waterways Experiment Station.
(*c*) Dr. J. B. Herbich and Dr. L. Z. Hales, Ocean Engineering Program.
(*d*) Experimental and analytical research.
(*e*) Changes occur in the characteristics of surface waves propagated in a region of streaming water. The velocity field of the wave motion interacts with the velocity distribution of the current pattern. The effect of the nonuniform current on the rate of energy propagation through the inlet was investigated by combining the results of the experiments with previously developed theoretical work. It was found that under certain specific conditions both flood and ebb currents enabled the waves to propagate more energy through the inlet than in the absence of a current as a result of the interaction of the two velocity fields.
(*f*) Completed.
(*h*) **Effects of a Steady Nonuniform Current on the Characteristics of Surface Gravity Waves,** L. Z. Hales, J. B. Herbich, *Misc. Paper H-74-11*, U.S. Army Engr. Waterways Exp. Station, Dec. 1974.
The Influence of Tidal Inlet Currents on the Propagation of Wave-Energy into Estuaries–Physical Model Indications, L. Z. Hales, J. B. Herbich, *Intl. Symp. River Mechanics*, Intl. Assoc. for Hydraulic Research, pp. C15-1-12, Bangkok, Thailand, 1973.
Tidal Inlet Current–Ocean Wave Interaction, L. Z. Hales, J. B. Herbich, *Proc. 13th Coastal Engrg. Conf.*, Chapter 36, pp. 669-688, Vancouver, B.C., Canada, 1972.

147-09048-590-22

THREE-DIMENSIONAL RESPONSE OF DEEP WATER LINES IN STEADY STATE FLOWS

(*b*) Naval Facilities Engineering Command.
(*c*) Dr. Richard F. Dominguez, Ocean Engineering Program.
(*d*) Theoretical and experimental; applied research.
(*e*) A systematic study of cable parameters in relation to deep water mooring applications under three-dimensional steady state loading conditions has been made. Included in this study are both negatively and neutrally buoyant cables in water depths from 5 to 25 thousand feet. A finite element model cable was used to predict three-dimensional configuration, cable reactions and internal stress distribution in the cable under directional hydrodynamic loading conditions.
(*f*) Completed.
(*g*) A systematic study of various hydrodynamic cable loading models indicated that the choice of loading criteria is rather arbitrary. Results are presented which permit direct evaluation of three-dimensional cable configurations and reactions for cables of arbitrary geometry, diameter and weight in currents up to one knot.
(*h*) **Three-Dimensional Response of Deep Water Mooring Lines in Steady State Flows,** R. F. Dominguez, G. E. Owens, *Texas A&M Univ. Rept. COE-157*, Dec. 1972.

147-09049-590-00

HYDRODYNAMIC FORCES ON CABLES SUBJECT TO FREQUENCY VARIED MOTION

(*c*) Dr. Richard F. Dominguez, Ocean Engineering Program.
(*d*) Experimental and theoretical; basic research.
(*e*) The dependency of hydrodynamic forces under unsteady, oscillatory conditions is studied with respect to the behavior of a highly flexible cable subjected to forced motion in a fluid. Experimental investigation is supplemented with the use of a finite element model of a cable structure.
(*g*) Results to date show that significant errors are possible by using classical descriptions based on the steady state derived added mass and drag coefficients for part of the cyclic loading history.
(*h*) **Hydrodynamic Forces on Cables Subject to Frequency Varied Motion,** R. W. Haas, R. F. Dominguez. Presented *16th Cong. Intl. Assoc. Hydraul. Res.*, San Paulo, Brazil, Aug. 1975.

147-09050-220-44

SCOUR AROUND OFFSHORE PIPELINES

(*b*) National Oceanic and Atmospheric Administration.
(*c*) Dr. J. B. Herbich, Ocean Engineering Program.
(*d*) Master's theses.
(*e*) Determine through physical modeling, the effect of storm waves on buried pipelines approaching and crossing the shoreline. Scour depth and scour patterns have been evaluated in a two-dimensional wave tank and future tests will be conducted in a wave basin to evaluate three-dimensional effects. Analysis of two-dimensional data indicates relationships between scour depth and wave height; scour length and wave length; and wave height and wave length/water depth for a range of wave steepness values. Estimates of burial depth have been made and are being verified experimentally. Rock cover is also considered in an effort to reduce burial depth. Forces on partially buried pipelines are measured in a laboratory wave channel.
(*h*) **Factors Influencing Equilibrium of a Model Sand Beach,** D. C. Smith IV, J. B. Herbich, *TAMU-SG-77-203*, Texas A&M Univ., 1976.
Scour Around Model Pipelines Due to Wave Action, J. B. Herbich, Honolulu, Hawaii, 1976.
Wave-Induced Scour Around Offshore Pipelines, J. B. Herbich, *Off-shore Technology Conf., OTC 2968*, Houston, Tex., 1977.

147-09051-420-44

WAVE INDUCED PRESSURE FIELDS AROUND A BURIED PIPELINE

(*b*) National Oceanic and Atmospheric Administration, Sea Grant Program.
(*c*) Dr. Richard F. Dominguez, Ocean Engineering Program.
(*d*) Theoretical and experimental; applied research.
(*e*) Numerical computer models using both the finite difference and finite element technique were developed to simulate the interaction of a two-dimensional wave system with a submerged pipeline and its surrounding soil media. Both computer models were validated by comparison with existing analytical and experimental results defining the pressure distribution in the soil media without a pipeline. Models are being used to study possible liquification failure phenomena and to establish rational criteria for designing offshore pipelines.
(*h*) **Numerical Solutions for Determining Wave-Induced Pressure Distributions Around Buried Pipelines,** N. W. Lai, R. F. Dominguez, Texas A&M Univ., *Sea Grant Rept. TAMU-SG-75-204*, Dec. 1974.

147-09054-370-47

PAVEMENT AND GEOMETRIC DESIGN CRITERIA FOR MINIMIZING HIGHWAY HYDROPLANING

(*b*) Federal Highway Administration, Office of Research and Development.
(*c*) Professors B. M. Gallaway, G. G. Hayes, Dr. D. L. Ivey, Dr. W. D. Ledbetter, Dr. R. M. Olsen, Dr. H. E. Ross, Jr., Dr. R. E. Schiller, Jr., Dr. Don Woods, Civil Engineering Department.
(*d*) Study of literature and reanalysis of previous Texas A&M University data on water films, hydroplaning, skid resistance. Use of computer program HVOSM to study vehicle control. Investigation of surface drainage criteria of the various State Highway Departments.
(*e*) A study involving required texture for portland cement concrete pavement surfaces to minimize hydroplaning; partial and full dynamic hydroplaning of vehicle tires; required texture and cross-slope combinations for asphalt concrete surfaces; the relationship of pavement cross slope to vehicle control; the hydraulic flow phenomena of thin films of water on pavement surfaces and under tires; and deficiencies in existing surface drainage design methodology for sag vertical curves.
(*f*) Project completed.
(*h*) **Pavement and Geometric Design Criteria for Minimizing Hydroplaning, Phase II, Final Report,** Federal Highway Admin., Office of Res. and Dev., Washington, D.C. 20590, Jan. 1979.
Technical Summary of Phase I and II Report, Dec. 1978.

147-09056-030-00

THE EFFECT OF VISCOSITY ON THE DYNAMICS OF A SUBMERGED SPHERICAL SHELL

(*c*) Dr. Jack Y. K. Lou, Ocean Engineering Program.
(*d*) Theoretical; basic.
(*e*) The axisymmetric vibrations of a spherical shell immersed in a compressible, viscous fluid are studied. The dynamic response of the shell is determined by the classical normal mode method while a boundary layer approximation is employed for the fluid medium.
(*g*) It is found that for free oscillation, fluid viscosity may produce noticeable effects on the damping components of the complex natural frequencies and is particularly important for the non-radiating modes. For forced vibrations, the present study reveals that the contribution of viscous effect is of small order, except in the vicinity of peak shell responses.
(*h*) **The Effect of Viscosity on the Dynamics of a Submerged Spherical Shell,** T.-C. Su, Y. K. Lou, presented *Vibrations Conf., ASME*, Sept. 17-19, 1975.

147-10579-330-10

PREDICTION OF THE BEHAVIOR OF DEEP-DRAFT VESSELS IN RESTRICTED WATERWAYS

(*b*) U.S. Army Corps of Engineers.
(*c*) Dr. J. B. Herbich.
(*d*) Applied research.
(*e*) Deep-draft navigation channel analysis, design and review is based on empirically-derived ratios of the design vessel's dimensions. Because of the radical changes in vessel operational purposes and characteristics, these ratios can no longer be safely or economically applied. The objective of this research is to develop a mathematical model which will provide the engineer with a comprehensive tool in the design and review of deep-draft navigation channels. The model will estimate values of squat, bank suction forces and moments, equilibrium drift and rudder angles and heights of ship-generated waves for varied channel configurations, ship positions and ship velocities.
(*h*) **Mathematical Models for the Design, Operation and Economic Analysis of Deep-Draft Navigational Channels,** E. T. Gates, J. B. Herbich, *SI-3, Proc. 24th Intl. Congress, PIANC*, Leningrad, U.S.S.R., Sept. 1977.
The Squat Phenomenon and Related Effects of Channel Geometry, E. T. Gates, J. B. Herbich, *Proc. 25th Ann. Hydraulics Div. Specialty Conf., ASCE*, Aug. 1977.
A Mathematical Model for the Review or Design of Deep-Draft Navigation Channels with Respect to Vessel Drift and Rudder Angles, E. T. Gates, J. B. Herbich, *Proc. Symp. Aspects of Navigability of Constraint Waterways Including Harbor Entrances, IAHR*, Delft, The Netherlands, Apr. 1978.

147-10580-330-00

SEDIMENT MOVEMENT INDUCED BY SHIPS IN RESTRICTED WATERWAYS

(*c*) Dr. J. B. Herbich.
(*d*) Applied research.
(*e*) A numerical model utilizing the momentum theory of the propeller and Shields' diagram is being developed to study sediment movement induced by a ship's propeller in a restricted waterway. The velocity distribution downstream of the propeller is simulated by the Gaussian normal distribution function and the shear velocity and shear stress were obtained using Sternberg's formulas.
(*h*) **Sediment Movement Induced by Ships in Restricted Waterways,** Y. C. Liou, J. B. Herbich, *TAMU-SG-76-209*, Texas A&M Univ., 1976.

Velocity Distribution and Sediment Motion Induced by Ship's Propeller in Ship Channels, Y. C. Liou, J. B. Herbich, *Proc. 25th Ann. Hydraulics Div. Specialty Conf., ASCE*, Aug. 1977.

147-10581-230-00

INFLUENCE OF THE SUPRAMOLECULAR MARINE ENVIRONMENT ON PITTING CORROSION

(*c*) Dr. D. B Harris, B. M. Gallaway, Materials Division, and Dr. J. B. Herbich, Ocean Engineering Program.
(*d*) Theoretical research.
(*e*) Process of corrosion pit nucleation in the marine environment is being investigated.
(*f*) Completed.
(*g*) Rupture of the passive film is described in terms of its sensitivity to attack by negatively hydrated ions. A corollary is suggested which describes the inhibiting effect of various positively hydrated ions. The role of marine microorganisms is being evaluated as it relates to those environmental modifications that may contribute to pit nucleation.
(*h*) **Influence of the Supramolecular Marine Environment on Pitting Corrosion,** D. B. Harris, B. M. Gallaway, J. B. Herbich, *TAMU-SG-76-211*, Texas A&M Univ., 1976.

147-10582-490-44

OFFSHORE MINING TECHNOLOGY

(*b*) Marine Board, Assembly of Engineering, National Research Council and NOAA.
(*c*) Dr. J. B. Herbich, Ocean Engineering Program.
(*d*) Applied research, planning.
(*e*) The study was to identify, assess and evaluate the technological needs for mining of hard minerals in both territorial and international waters. Of particular interest in this part of the study was the evaluation of sand, gravel and shell mining.
(*g*) Present methods of recovering sand, gravel and shell have been reviewed and recommendations will be made to improve efficiency and lessen the environmental impact.
(*h*) **Recovery of Sand, Gravel and Shell From the Ocean,** a brief summary of Technology Development Projects Sponsored by NOAA, *CDS Rept. No. 191*, Center for Dredging Studies, Texas A&M Univ., Mar. 1976.
Technological Gaps and Environmental Effects, J. B. Herbich, *Paper E1, Proc. Intl. Symp. Dredging Technology, BHRA and TAMU*, Nov. 1977.
Technological Gaps in Deep Ocean Mining, J. B. Herbich, J. E. Flipse, *OCEANS '78, MTS–IEEE, 4th Ann. Conf. Ocean Challenge*, Washington, D.C., Sept. 1978.

147-10583-330-44

ENVIRONMENTAL CONSIDERATIONS OF THE OPERATION AND MAINTENANCE OF THE TEXAS GULF INTRACOASTAL WATERWAY

(*b*) Sea Grant.
(*c*) Dr. Wesley P. James, Civil, Coastal, Hydraulic and Ocean Engineering Group.
(*d*) Applied research.
(*e*) Study provides baseline environmental information from literature reviews and a field sampling program. It gives a basic understanding of the environmental aspects of intracoastal waterway transportation system including evaluation of activities directly associated with waterway and the potential of the waterway to transport pollutants from one area of the coast to another.
(*f*) Project completed January 1977.
(*g*) Poor water quality in the channel was generally associated with fresh water inflows. A model was developed to evaluate the flow between Galveston Bay and Sabine Lake. Satellite imagery of the Lower Laguna Madre was used to evaluate flow patterns in bays. High shoaling rates were located where the prevailing flow patterns crossed the channel.
(*h*) **Environmental Considerations Relating to Operation and Maintenance of the Texas Gulf Intracoastal Waterway,** W. P. James, S. Giesler, R. DeOtte, M. Inoue, Texas A&M University, Sea Grant College, Nov. 1977.

147-10584-810-33

POTENTIAL IMPACT OF THE DEVELOPMENT OF LIGNITE RESERVES ON WATER RESOURCES OF EAST TEXAS

(*b*) Office of Water Resources Research.
(*c*) Dr. Wesley P. James, Coastal, Hydraulic and Ocean Engineering Group.
(*d*) Applied research.
(*e*) Project was concerned with identifying potential adverse effects of lignite strip mining and lignite utilization on the hydrology and water quality of the area. Both field and desk studies were conducted to evaluate the potential impact of lignite development on water resources of the area. Field studies included (1) monthly water sampling for a one-year period of streams, lakes and wells near the strip-mined areas at Fairfield and Rockdale and at control stations located away from the lignite development; (2) leaching studies of the lignite and overburden at Fairfield and Rockdale; (3) precipitation samples collected under the airborne waste plume from the lignite-fueled electric generating plant at Fairfield; and (4) a limited trace element enrichment study in the soils around the plant at Fairfield.
(*f*) Project completed August 1976.
(*g*) Strip mining can change the hydrologic characteristics of the area and full development of the near-surface lignite reserves in east and east central Texas could have a significant impact on the groundwater resources of the region.
(*h*) **Potential Impact of the Development of Lignite Reserves on Water Resources of East Texas,** W. P. James, J. F. Slowey, R. L. Garrett, C. Ortiz, J. Bright, T. King, Texas Water Resources Inst., Texas A&M Univ., Aug. 1976.

147-10585-800-33

ENVIRONMENTAL EVALUATION OF WATER RESOURCES DEVELOPMENT

(*b*) Office of Water Research and Technology.
(*c*) Dr. Wesley P. James, Coastal, Hydraulic and Ocean Engineering Group.
(*d*) Applied research.
(*e*) The environmental effects of channelization and surface impoundments are discussed for twelve physiographic regions of Texas as delineated on black and white satellite (LANDSAT-1) mosaic of band 7. With the aid of LANDSAT-1 imagery, representative or typical transects were chosen within each region. Profiles of each site were constructed from topographic maps and environmental data were accumulated for each site and related to low altitude aerial photography and enlarged LANDSAT-1 false color composites.
(*f*) Project completed July 1976.
(*g*) Each diagrammatic transect, with accompanying data and photographs, provides significant information for input of environmental amenities on a local and regional scale into preliminary water resources development studies. The utilization of the transects provides a visual display of available information, aids in the identification and inventory of resources, assists in the identification of data gaps and provides a planning tool for additional data acquisition.
(*h*) **Environmental Evaluation of Water Resources Development,** W. P. James, C. E. Woods, R. E. Blanz, Texas Water Resources Inst., Texas A&M Univ., July 1976.

147-10586-330-44

SHOALING CHARACTERISTICS OF THE GULF INTRACOASTAL WATERWAY IN TEXAS

(*b*) Sea Grant.
(*c*) Dr. Wesley P. James, Coastal, Hydraulic and Ocean Engineering Group.
(*d*) Applied research.

(*e*) Maintenance dredging records were used to compute average shoaling rates in 5000-foot reaches for the entire Texas Gulf Intracoastal Waterway. Environmental data pertinent to the waterway were gathered from published and unpublished sources. Computed shoaling rates and selected environmental features were plotted on Composite Factors Maps. Similar reaches were grouped and examined using analysis of variance techniques to determine the effect of selected environmental factors on shoaling rates. A model was also developed to predict shoaling rate in a reach with known environmental factors.
(*f*) Project completed May 1976.
(*g*) The average shoaling rate over the entire waterway was found to be 10.5 inches per year. Shoaling in open bay areas was found to be an average of 3 inches per year greater than in land-cut areas. The combination of dredged material mounds, or fetch greater than 5 miles, with water depths less than 6 feet (surrounding bay depth) increased average shoaling rates 5 inches per year. The placement of dredged material in mounds on the windward side of the waterway increased the average shoaling rate of open bay areas by 7 inches per year. In bay areas with long fetches and depths less than three feet, it was found that windward placement of dredged material was actually advantageous. Hurricanes did not appear to have a drastic impact on shoaling rates; however, localized effects were noted in several areas.
(*h*) **Shoaling Characteristics of the Gulf Intracoastal Waterway in Texas,** J. M. Atturio, D. R. Basco, W. P. James, Civil Engrg. Dept., Coastal and Ocean Engrg. Div., *TAMU-SG-76-207, CDS Report No. 187*, May 1976.

147-10587-870-43

ENVIRONMENTAL CONSIDERATIONS OF BRINE DISPOSAL

(*b*) Federal Energy Administration.
(*c*) Dr. Wesley P. James, Coastal, Hydraulic and Ocean Engineering Group.
(*d*) Applied research.
(*e*) Pursuant to the requirements of the Energy Policy and Conservation Act of 1975, the Federal Energy Administration proposes to implement the Strategic Petroleum Reserve. One hundred fifty million barrels of oil are to be stored by December 22, 1978, in the Early Storage Reserve, and at least 500 MMB are to be stored by December 22, 1982, under the full program. Among the storage options studied, the most attractive from an economic and environmental standpoint is storage in solution-mined salt cavities near existing petroleum distribution facilities along the Gulf of Mexico coast. Water quality is one of the most critical among the sensitive environmental issues and large quantities of raw water will be required and large quantities of brine will be produced in the construction and operation modes of solution-mined caverns. Disposal of brine into the sea is an alternative being considered for seven of the sites.
(*f*) Project will be completed September 1, 1977.
(*g*) Workshop was held to identify environmental concerns of brine disposal. These included interference with migration of marine organisms into estuaries, damage to shrimp larvae caused by high jet velocity at diffuser, oil in brine during refill operations, and water quality at the boundary of the mixing zone. Bioassays were recommended along with preconstruction and operational monitoring of the disposal area. Laboratory model tests were conducted of the jet on the diffuser to determine the influence of nozzle diameter, jet velocity and riser height on the resulting brine concentration at the ocean bottom.
(*h*) **Proceeding of Strategic Petroleum Reserve Workshop–Environmental Considerations of Brine Disposal Near Freeport, Texas,** Texas A&M Univ., Sea Grant, Apr. 1977.
Wind Direction, Wind Speed, and Dry Bulb Air Temperature for Beaumont/Port Arthur, Texas, 1969 through 1973, Texas A&M Univ., Sea Grant, Aug. 1977.
Dilution of a Dense, Vertical Jet in A Stagnant Homogeneous Fluid, Texas A&M Univ., Sea Grant, Jan. 1979.

147-10588-330-00

MAJOR PORT IMPROVEMENT ALTERNATIVES FOR THE TEXAS COAST

(*c*) Dr. J. B. Herbich, J. W. Berriman, Ocean Engineering Program.
(*d*) Applied research.
(*e*) With the advent in recent years of very large commercial craft (VLCC) and ultra large commercial craft (ULCC), the U.S. ports have fallen behind many other maritime countries in providing suitable docking facilities.
(*g*) Ship channel design criteria have been reviewed in terms of minimum width and depth requirements for various size vessels. Improved channel designs are considered for the ports of Port Arthur, Galveston, Freeport and Corpus Christi, Texas.
(*h*) **Major Port Improvement Alternatives for the Texas Coast,** J. W. Berriman, J. B. Herbich, *TAMU-SG-77-205*, 1977.
Major Port Improvement Alternative, J. W. Berriman, J. B. Herbich, *Proc. 25th Ann. Hydraulics Div. Specialty Conf., ASCE*, Aug. 1977.
Port Improvement Design Criteria, J. W. Berriman, J. B. Herbich, *Paper WW4, J. Waterway, Port, Coastal and Ocean Div., ASCE*, Nov. 1977.

147-10589-430-00

BENEFICIAL USES OF DREDGED MATERIALS

(*b*) Center for Dredging Studies.
(*c*) Dr. J. B. Herbich and Mr. B. S. Hubbard, Ocean Engineering Program.
(*d*) Applied research, documentation.
(*e*) A review of an international list of publications was made to gather examples of locations where dredged material was put to a productive use. Mail questionnaires revealed about 143 sites where dredged material, as a by-product of maintenance of capital dredging, was put to productive use. The classifications were commercial, industrial, recreational, wildlife habitats, agricultural, hydraulic control, transportation, future and research, and miscellaneous.
(*g*) Analysis of results to-date indicate the commercial and industrial uses to be the most prevalent. Maintenance dredging generated the material for most of the sites. Sound planning for the disposal of material generated from each dredging project has become a necessary consideration.
(*h*) **Productive Land Use of Dredged Material Containment Areas: International Literature Review,** B. S. Hubbard, J. B. Herbich, *CDS Report No. 199*, Center for Dredging Studies, TEES, Texas A&M Univ., 1977.
Productive Land Use of Dredged Material Containment Areas, B. S. Hubbard, J. B. Herbich, *Proc. 25th Ann. Hydraulics Div. Specialty Conf., ASCE*, Aug. 1977.
Productive Land Use of Dredged Material, B. S. Hubbard, J. B. Herbich, *Paper F1, Proc. 2nd Intl. Symp. Dredging Technology, BHRA and TAMU*, Nov. 1977.

147-10590-590-00

APPLICATION OF THE FINITE ELEMENT METHOD TO TOWED CABLE DYNAMICS

(*c*) Dr. Y. K. Lou, J. Ketchman, Ocean Engineering Program.
(*d*) Basic, theoretical.
(*e*) Project deals with towing an object through a fluid by means of a cable. For a slender, neutrally buoyant towbody, the planar configuration of the towed system is determined for steady motion and for time-dependent maneuvers of the towing vehicle. A formulation of the finite element method that applies to towed cable dynamics is presented including bending deformation and stretch of the elements, and nodal forces caused by acceleration, distributed weight, and hydrodynamic loading. Although based on established forms for fluid drag, the treatment and expressions for nodal hydrodynamic loading forces are new. The resultant system of equations for the unknown nodal displacements is solved by step-by-step integration in

time using a scheme that eliminates troublesome longitudinal oscillations. Lumped and distributed systems are compared with respect to the treatment of mass and hydrodynamic loading and the effects of bending stiffness are illustrated.

(*f*) Completed.

(*h*) **Application of the Finite Element Method to Towed Cable Dynamics,** J. Ketchman, Y. K. Lou, *Proc. Ocean 1975 Conf.*, pp. 98-107, Sept. 1975.

147-10591-350-75

MODEL TESTS OF SPILLWAY AND STILLING BASIN, COLETO CREEK DAM, NEAR VICTORIA, TEXAS

(*b*) Forrest and Cotton, Dallas, Tex.

(*c*) Dr. John B. Herbich and Dr. R. E. Schiller, Jr., Professors of Civil and Ocean Engineering.

(*d*) Experimental.

(*e*) The testing program involved testing of a two-dimensional model (three bays of a total of seven) on a 1/50-scale of the spillway, tainter gates and low Froude number stilling basin to establish the design of piers, length of stilling basin and placement of blocks in the stilling basin. A three-dimensional model (1/100-scale) was then tested at flow rates up to a prototype value of 306,000 cfs to establish proper design of the approaches to the spillway. The three-dimensional model (except the spillway and stilling basin) was constructed of fiberglas over hardware cloth.

(*f*) Experimental work completed.

(*h*) **Hydraulic Model Study of Coleto Creek Dam,** J. B. Herbich, R. E. Schiller, Jr., B. Hubbard, W. Y. Chow, *Rept. No. COE-198*, Texas A&M University, Sept. 1978.

147-11109-410-44

EROSION OF DREDGED MATERIAL ISLANDS DUE TO WAVES AND CURRENTS

(*b*) NOAA, Sea Grant Program.

(*c*) Dr. John B. Herbich, Center for Dredging Studies.

(*d*) Experimental and analytical.

(*e*) Develop empirical capability of predicting the erosion rates of cohesionless dredged material islands for wave and wind environment similar to that of the Upper Laguna Madre, Texas. The field and the historical data for a selected dredge material island (Crane Island) were employed in conducting the preliminary movable-bed model study. The degree of reliability of the preliminary model studies was established by comparing their results with the prototype results. A general model study was conducted to investigate the separate effect of various factors such as different water depths, island spacing, island orientation and presence of small magnitude current on the island erosion rates. The increase in the water depth cuased an increase in the island erosion rates. Once the eroded material settled down on the bottom, it experienced very little disturbance. The island migration rate and hence the channel silting rate under the higher water depths (0.72 ft and 0.80 ft) were found to be insignificant. The island erosion rates decreased with decreasing spacing. The islands having spacing of 50 ft and built parallel to the incident wave crests (0 orientation) offered the most economical solution in terms of the long-term maintenance dredging. The islands were also tested for two more orientations, 45° and 90° with respect to the incident waves. The overall erosion of the islands was affected only slightly by different orientations. The islands built at 0° orientation offered slightly more resistance to wave erosion than the islands at 45° or 90° orientation. Some of the model tests were repeated for combined action of waves and current. A current of 0.5 ft/sec (1 ft/sec in prototype) was super-imposed on the incident waves. The horizontal dispersion of the sediment material and hence the channel silting rates increased significantly. A method for evaluating bottom shear stress under combined action of waves and currents has been recommended.

(*f*) Physical model study completed.

147-11110-410-00

BULKING FACTORS FOR TEXAS COASTAL DREDGED MATERIAL

(*b*) Center for Dredging Studies.

(*c*) Dr. John B. Herbich, Center for Dredging Studies, Dr. Wayne Dunlap, Geotechnical Group.

(*d*) Experimental.

(*e*) Laboratory determination of bulking factors for 27 different soil samples representing a variety of consolidated sandy and silty clays typical to the Texas coastal area. The laboratory methodology is similar to that recommended by Lacasse, et al., 1977, but includes the use of a special impeller to simulate the dredging process in preparing soil slurries. Sedimentation tests are conducted in 1000 ml graduated cylinders and observed for periods ranging from 5 to 30 days. The effects of varying cylinder size and water salinity are also investigated. The results indicate that bulking factors decrease with increasing water salinity, and that significant flocculation of soil particles occurs at water salinities as low as 13 percent. The results also indicate that bulking factors tend to increase with increasing h/d ratios, where h is the height of slurry initially placed in the cylinder, and d is the cylinder diameter. Equations derived from the data are presented, and relate bulking factors to such soil variables as containment area average void ratio, percent silt and clay, in situ water content, and Atterberg limits. Use of these equations to predict the laboratory observed bulking factors results in an accuracy ranging from 0 18 percent to 0 30 percent.

147-11111-220-00

SCOUR AROUND A GROUP OF PILES DUE TO OSCILLATORY WAVE MOTION

(*b*) Ocean Engineering Program.

(*c*) Dr. John B. Herbich, Ocean Engineering Program.

(*d*) Experimental.

(*e*) Scour caused by three different arrays and two different pile diameters of pile groups was studied in a two-dimensional wave flume using natural sands. Through dimensional analysis the influential parameters are developed and the data collected were studied to determine the functional relationships between the parameters. The primary objective of the study was to determine the parameters that control the ultimate scour depth of a pile group due to oscillatory wave motion.

(*h*) **Scour Around a Group of Piles,** W. Y. Chow, J. B. Herbich, *Paper OTC 3308*, *Offshore Technology Conferenece*, Houston, 1978.

147-11112-860-50

INVENTORY OF SURFACE WATER USING LANDSAT DATA

(*b*) NASA.

(*c*) Dr. John B. Herbich, Coastal, Hydraulic and Ocean Engineering Group.

(*d*) Experimental and analytical.

(*e*) Specific objectives of this investigation were: (1) To define and document a procedure by which LANDSAT multispectral scanner data can be used to detect, identify, and estimate the areal extent of individual bodies of surface water. (2) Using this procedure and a data set corresponding to a study site within which the size and location of all bodies of surface water greater than 0.81 hectare are known, determine the level of accuracy to shich one can detect and identify and estimate the areal extent of each body of surface water.

A detailed procedure for using LANDSAT multispectral scanner data to detect, identify, and estimate the areal extent of individual bodies of surface water was defined, documented, and then used to process the selected LANDSAT data.

The LANDSAT data chosen for this investigation represented a situation wherein classes of natural surface

cover (wet, dark-black, bare soils) provided a significant amount of confusion during the spectral-separability phase of classification. The study site selected for this investigation covered approximately 132,000 hectares in east-central Texas and contained 100 bodies of surface water that ranged in size from 0.83 hectare to 17.48 hectares.

The classification results, using the recommeded procedure, contained no areas in the study site which had been identified as water which were actually nonwater. The identification results also showed that 58 percent of the 69 water bodies ranging in size from 0.81 hectare to 2.02 hectares and 33.3 percent of the 15 water bodies ranging in size from 2.03 hextares to 4.04 hectares were misclassified as nonwater. However, the identification results showed that all 16 water bodies 4.05 hextares or greater were correctly identified as water.

Analysis of the estimates of the areal extent of each of the 55 water bodies correctly identified as water showed the following: (a) A high correlation ($R = 0.97$) between the actual surface area and the estimated surface area. (b) A least-squares, linear regression of the actual surface area on the estimated area which accounts for 94 percent of the variation in the actual surface area present in the study site. (c) Estimates of the areal extent of bodies of surface water ranging in size from 0.81 hectare to 2.02 hectares contained a positive bias. However, the areal estimates for bodies of water ranging in size from 2.03 hectares to 17.48 hectares were unbiased.

A comparison of the actual shape of the individual bodies of water in the study site with the classification results showed a potential increase in both the accuracy of identification of water bodies ranging in size from 0.81 hectare of 4.04 hectares and in the precision of the areal estimates if satellite-acquired, spectral data with a higher spatial resolution and a higher signal-to-noise ratio were available.

It is concluded that agencies and operational organizations at the federal, state, and local levels could routinely utilize LANDSAT multispectral scanner data to compile a baseline inventory of the surface water in a selected geographic region and periodically update these inventories to provide a monitoring capability.

However, it should be pointed out that the data preprocessing, and the data processing steps, in this investigation were accomplished using a collection of software programs that were developed for use in a research and development environment. For an operational organization to routinely use the recommended procedure, these software programs would need to be reconfigured to operate in a more cost-effective manner.

147-11113-430-00

NUMERICAL TECHNIQUES FOR THE DYNAMIC ANALYSIS OF SUBMERGED SHELLS

(*c*) Dr. Y. K. Lou, Ocean Engineering Program.
(*d*) Theoretical, applied.
(*e*) Develop a numerical technique and compute programs suitable for the dynamic analysis of submerged elastic shells.
(*g*) A method is developed for the evaluation of the displacements and the surface pressure which are induced by the harmonic excitation of a shell of revolution submerged in an acoustic medium. The method utilizes a source distribution approach for the acoustic medium and a finite element for the shell structure. Compatibility conditions on the fluid-shell interface allow the unknown source strengths and the radiated pressure to be expressed in terms of the unknown shell displacements. By coupling the radiated pressure with the equations of motion of the shell, the displacements can be determined by Gaussian elimination. The radiation pressure can thus be determined accordingly. Numerical results for spherical shells with various loading conditions are obtained and compared with exact solutions.
(*h*) **Dynamic Analysis of Shells of Revolution Submerged In An Acoustic Medium By the Finite Element Method,** C. K. Ng, Y. K. Lou, Texas A&M University, *COE Report No. 215*, June 1978.

147-11114-430-00

NATURAL FREQUENCIES OF SUBMERGED SPHERICAL SHELLS

(*c*) Drs. T. C. Su and Y. K. Lou, Ocean Engineering Program.
(*d*) Theoretical, basic.
(*e*) Free vibrations of a spherical shell submerged in a fluid medium are investigated. It is found that no undamped natural frequency of the submerged shell can exist even if the surrounding fluid is assumed inviscid. In this case the damping is solely due to the compressibility of the fluid. However, for the intermediate modes, the damping components of the complex frequencies are extremely small, thus, an almost steady-state, undamped free oscillation is possible for these modes and a pronounced resonance may be observed for the forced vibrations. The effect of fluid viscosity on the complex natural frequencies has also been examined. It is found that for small viscosities, the viscosity has essentially no effect on the real component of the natural frequencies.
(*f*) Completed.
(*h*) **Free Oscillations of Submerged Spherical Shells,** Y. K. Lou, T. C. Su, *J. Acoustics Soc. 63(5)*, pp. 1402-1408, May 1978.

147-11115-870-44

EVALUATION OF BRINE DISPOSAL FROM THE BRYAN MOUND SITE OF THE STRATEGIC PETROLEUM RESERVE PROGRAM

(*b*) National Oceanic and Atmospheric Administration.
(*c*) R. E. Randall, Ocean Engineering Program.
(*d*) Experimental; applied research, M.S. thesis.
(*e*) The Strategic Petroleum Reserve Program is storing oil in large salt dome caverns located along the Gulf of Mexico coast. When the oil is pupmped into the caverns, the displaced brine is planned to be discharged into the Gulf of Mexico. The purpose of the present study is to collect information on the present environmental conditions in the coastal waters near Freeport, Texas which is one of the prime storage locations. This study was begun in September, 1977 and the areas of investigation are physical oceanography, nekton and benthic environment, water and sediment quality, and the development of a method for tracking a brine plume.
(*h*) **Evaluation of Brine Disposal from the Bryan Mound Site of the Strategic Petroleum Reserve Program,** *Progress Reports*, R. W. Hann, Jr., R. E. Randall, et. al., Dec. 1977, July 1978, and Feb. 1979.

147-11116-210-00

DYNAMICS OF A CANTILEVER PIPE CONVEYING FLUID

(*c*) Dr. Y. K. Lou, Ocean Engineering Program.
(*d*) Experimental, applied.
(*e*) Investigate the effect of internal pipe flow on the dynamic behavior of a cantilever pipe.
(*f*) Suspended.
(*g*) An experimental study is conducted to investigate the effects of internal flow rate and the depth of immersion on the dynamic response of a cantilever pipe discharging a fluid. It is found that the internal flow rate and the surrounding fluid have a significant effect on the natural frequencies of the system. Therefore, depending on the relative magnitude of the forcing frequency, an increase in flow rate may not necessarily result in a larger system response. Conversely, an increase in the length of pipe immersion does not necessarily decrease the dynamic response of the system. It is also observed that with increasing flow rate, an auspicious increase in the response

to the higher harmonics is noted, indicating an increased fluid coupling of the system.

(*h*) **The Effect of Internal-Flow On The Dynamic Responses of A Cantilever Pipe,** R. B. Shilling, III, Y. K. Lou, *Energy Technology Conf. and Exhibition*, Houston, Tex., Nov. 5-9, 1978.

147-11117-420-00

LOCAL SCOUR CAUSED BY WAVES AROUND VERTICAL CYLINDERS

(*b*) Texas Engineering Experiment Station.
(*c*) Dr. J. B. Herbich.
(*d*) Experimental, M.S. thesis and research reports.
(*e*) A two-dimensional wave flume is used in evaluating scour around vertical piles due to wave action. The variables include the wave characteristics, different pile arrays and the spacing between piles. The experimental data are used to develop functional relationships between different parameters.
(*h*) **Scour Around a Group of Piles,** W. Y. Chow, J. B. Herbich, *OTC 3308, Proc., Offshore Technology Conf.*, 1978.

147-11118-430-00

WAVE RUNUP ON PILES AND PILE GROUPS

(*b*) Texas Engineering Experiment Station.
(*c*) Dr. J. B. Herbich.
(*d*) Experimental, M.S. thesis.
(*e*) A wave which interacts with a vertical pile experiences a transformation, resulting in a water level increase in front of the pile which is generally known as runup or uprush. Concurrently, a cavity known as drawdown or downrush is formed behind the pile. Wave flow patterns around single piles have been investigated previously but apparently no studies were conducted on pile groups in the past.

The purpose of the study was to observe the flow pattern caused by waves around thin single piles, around pile groups and inclined piles. A thin pile was defined when its diameter is much less than a wavelength. Previous studies on wider piles were reviewed to gain a complete understanding of runup.

Wave runup on piles, in addition to being of general interest, has several practical applications. For example, the runup must be taken into account when determinig the appropriate deck clearances on pile-supported piers and offshore platforms, to avoid the large forces which could result from waves striking the piers' deck or platform's lower deck. Runup and drawdown can also have significant effects on the wave forces encoutered by piles.

Another application of the results of runup studies is its use as a device to record wave direction for the purpose of evaluating directional wave spectra, or for study of sediment transport.

The results of the study show that the relationship between runup and velocity head can be used for piles with scattering parameters as small as 0.0105. However, just below this value, runup decreases rapidly as a function of the scattering parameter.

The results also indicate that despite the interaction between cylinders in pile groups, the crest velocity head is a good measure of the magnitude of runup. No significant increase in runup is caused by the interaction of the three piles. The conclusions of this study would hold equally true for pile groups of more than three.

Design curves are presented for estimates of runup Dimensionless peak water level above still water level at pile for orientation angle $\propto$ is plotted as a function of $\pi D/L$ for different values of $U^2/2gP$. (D-pile diameter, L = wave length, U = peak horizontal water particle velocity and P = incident crest height).

147-11119-420-44

WAVE DATA BANK FOR TEXAS

(*b*) National Oceanographic and Atmospheric Administration, Department of Commerce.
(*c*) Dr. J. B. Herbich, Ocean Engineering Program.
(*d*) Experimental, field investigation, basic research.
(*e*) The fact that little information is available relating to wave characteristics for the Texas coast has plagued all those involved with planning and utilization of the coastal environment. This project will continue a wave monitoring program aimed at development of a long-term predictive tool. This will be accomplished by using conditions with "waverider buoys" and pressure type meters at selected locations off the Texas coast. Wave recorders of approximately 15 minutes in length are recorded in real-time at four-hour intervals. During data processing, either Fourier Transform or Fast Fourier Transform computer algorithms are used, resulting in an energy density spectrum. Comparison of wave height climates for different seasons, years of locations is accomplished using statistical models for the prediction of long-term wave characteristics.

147-11120-330-75

BEHAVIOR OF DEEP-DRAFT VESSELS IN THE PROPOSED, DEEPENED GALVESTON SHIP CHANNEL

(*b*) Espey-Huston Consulting Engineers.
(*c*) Dr. J. B. Herbich, Ocean Engineering Program.
(*d*) Applied research, development.
(*e*) Investigate the effect of squat, bank suction, and drift on the performance of an oil-tanker traversing the proposed deep-draft channel at Galveston. A computer simulation model developed in 147-10579-330-10 was adapted for the proposed channel. The model predicts the behavior of a deep-draft vessel in a restricted waterway by employing both theoretical and empirical relationships. The operational characteristics were investigated for various changes in channel geometry (squat and bank suction) and environmental forces (wind and currents). The effects of each of the above conditions were combined to determine the total operational characteristics. The ship-generated waves as well as the required distance to stop the vessel were also investigated for each of the conditions.

147-11121-300-65

STUDY OF HYDRAULIC CHARACTERISTICS OF SAN LUIS PASS AND EROSION POTENTIAL OF EASTERN PART OF THE PASS

(*b*) County of Galveston, Texas.
(*c*) Dr. J. B. Herbich.
(*d*) Field investigation, design.
(*e*) Field measurements will be made to provide additional information for the development of characteristics of San Luis Pass. Mathematical model will be employed to predict future changes in the Pass characteristics. Measures to protect bridge abutments will be recommended.

TEXAS A&M UNIVERSITY, Texas Water Resources Institute, College Station Tex. 77843. Dr. J. R. Runkles, Institute Director.

148-0386W-820-33

SIMULATION OF POLLUTANT MOVEMENT IN GROUND-WATER AQUIFERS

(*b*) OWRT.
(*c*) Dr. Donald Reddell.
(*e*) See WRRC 10, 4.0056.
(*f*) Completed.

148-0387W-870-33

TREATMENT OF WOOD PRESERVING WASTEWATER

(*b*) OWRT.

(c) Dr. Tom Reynolds.
(e) See WRRC 10, 5.0668.
(f) Completed.

148-0390W-840-33

ESTIMATION OF THE ECONOMIC DEMAND FOR IRRIGATION ON THE HIGH PLAINS AND RIO GRANDE PLAIN REGIONS OF TEXAS

(b) OWRT.
(c) Dr. Bruce Beattie.
(e) Estimate and aggregate crop production function for the High Plains and Rio Grande Plains region of Texas using least-squares regression techniques; derive the marginal value productivity of irrigation water from the fitted production functions; derive irrigation water demand functions of water "price," product price, and prices of other inputs; and derive price elasticities of water demand with respect to own (water) "price," product price and prices of other inputs, e.g., energy, fertilizer and labor.
(f) In press.

148-0391W-870-33

DESIGN AND DEMONSTRATION OF A NON-CONVENTIONAL DENITRIFICATION SYSTEM

(b) OWRT.
(c) Dr. Robert Sweazy, Texas Tech University, Lubbock, Tex. 79409.
(e) Investigate the feasibility of denitrifying sewage effluent by a nonconventional method and demonstrate the system and optimize the process design. The nitrification process, conversion of ammonia to nitrate, will be stopped at the nitrite step, and then denitrification will be promoted.
(f) Completed.

148-0392W-800-33

LEGAL ASPECTS OF LAND USE REGULATION OF LAKE SHORELANDS BY STATE AND LOCAL GOVERNMENTS FOR THE PROTECTION OF LAKES

(b) OWRT.
(c) Dr. Corwin Johnson, University of Texas, Austin, Tex. 78712.
(f) Completed.

148-0393W-840-33

THE IMPACT OF ENERGY SHORTAGE ON IRRIGATION IN THE HIGH PLAINS AND TRANS PECOS REGIONS OF TEXAS

(b) OWRT.
(c) Dr. Ronald Lacewell.
(e) Estimate the impact of natural gas curtailment of a given duration in selected periods of time on crop yields and net returns in the High Plains region; estimate the impact of natural gas price increases in the High Plains and Trans Pecos regions on irrigated acreage and groundwater use, cropping patterns and output levels, and net income to the producer; evaluate the net benefits of increasing pumping efficiency on the High Plains under selected levels of natural gas prices; and evaluate the net benefits of improving soil and water management practices in the Trans Pecos under selected levels of natural gas prices.
(f) Completed.

148-0394W-800-33

OPTIMAL USE OF GROUNDWATER AND SURFACE WATER TO REDUCE LAND SUBSIDENCE

(b) OWRT.
(c) Dr. Donald Reddell.
(e) Develop a three-dimensional model for evaluating pressure distributions in a multi-aquifer-aquitard system; develop a pressure-dependent model to determine amount of land subsidence from pumping and develop an optimization model.
(f) In press.

148-0395W-820-33

HEAT TRANSPORT IN GROUNDWATER SYSTEMS

(b) OWRT.
(c) Dr. Donald Reddell.
(e) Develop a computer simulation of the simultaneous movement of mass and energy (heat) in a groundwater aquifer with fluid density and viscosity variations; verify the numerical model with laboratory and field hot water injection systems; and evaluate the feasibility of storing hot water in groundwater aquifers.
(f) In press.

148-0396W-810-33

EVALUATION OF THE IMPACT OF TEXAS LIGNITE DEVELOPMENT ON TEXAS WATER RESOURCES

(b) OWRT.
(c) Dr. C. C. Mathewson.
(e) Determine the water utilization of existing steam-turbine power plants as a function of power generation; determine the water used during the mining and transport of lignite and for the reclamation of strip mined areas in terms of acre-foot of lignite mined; determine the surface water and groundwater resources available for energy development throughout the lignite area in Texas; and determine the impact of lignite development on the water resources in the lignite area.
(f) In press.

148-0397W-840-33

NEW IRRIGATION SYSTEM DESIGN FOR MAXIMIZING IRRIGATION EFFICIENCY AND INCREASING RAINFALL UTILIZATION

(b) OWRT.
(c) Dr. William Lyle.
(e) Maximizing overall water use efficiency in agricultural production: maximize irrigation efficiency, including both application and distribution efficiency and obtain greater retention and utilization of rainfall, thereby, decreasing irrigation demand.

148-0398W-880-33

PROBLEMS OF PUBLIC ACCESS TO WATER IN TEXAS LAKES AND STREAMS: AN ANALYSIS

(b) OWRT.
(c) Dr. Otis Templer, Texas Tech University, Lubbock, Tex. 79409.
(e) Review existing Texas land and water law relating to public access, and to examine the institutional or legal constraints inherent in the law which affect public use of the water, beds and banks of streams and lakes; suggest the most feasible and desirable modifications or alternatives to the present legal system to help lessen the conflicts between the public and landowners on streams and lakes; develop case studies of several representative Texas streams and lakes to illustrate the problems of public access and the impediments to access and recreational use; investigate the development of a classification system identifying those streams and thus subject to public use; and inform water and land resource decision-makers, the recreation-seeking public and property owners along streams and lakes of the findings of this study in order to better define the respective rights and duties of the various factions and interest groups.
(f) Completed.

148-0399W-810-33

METHODOLOGY FOR ANALYZING EFFECTS OF URBANIZATION ON WATER RESOURCE SYSTEMS

(b) OWRT.
(c) Dr. Larry Mays, University of Texas, Austin, Tex. 78712.
(e) Develop a model for analyzing the effects of urbanization on urban water systems, in particular, storm drainage systems.
(f) Completed.

148-0404W-820-33

INSTITUTIONAL ARRANGEMENTS FOR EFFECTIVE GROUNDWATER MANAGEMENT TO HALT LAND SUBSIDENCE

(*b*) OWRT.
(*c*) Dr. Lonnie Jones.
(*e*) Assess existing institutions within the area with regard to their effectiveness in managing conjunctive groundwater and surface water uses; examine groundwater management systems in other regions to determine their applicability to problems within the study area and develop alternative comprehensive water management schemes which might be used to control land surface subsidence through conjunctive groundwater and surface water use.
(*f*) Completed.

148-0406W-800-33

ANALYSIS OF PRIORITY WATER RESOURCES FOR THE SOUTHERN PLAINS REGION

(*b*) OWRT.
(*c*) Dr. J. R. Runkles.
(*e*) Develop a detailed description of the major research accomplishments in the region; identify and describe the major research accomplishments in terms of potential for technology transfer within the region; develop priority programs for technology transfer within the region and submit proposals to OWRT for technology transfer programs to be conducted by the Southern Plains Region.
(*f*) Completed.

148-0409W-820-33

UTILITY ANALYSIS FOR THE URBAN GROWTH INSIDE THE RECHARGE ZONES OF GROUNDWATER RESOURCES IN SAN ANTONIO AREA

(*b*) OWRT.
(*c*) Dr. C. S. Shih, University of Texas at San Antonio, San Antonio, Tex. 78285.
(*e*) Develop an integrated approach based on decision and utility theory, factor analysis, and the socio-economic analysis techniques for the optimal decision analysis of managerial and planning alternatives toward the maximum land utilization and protection of the high-quality groundwater for San Antonio area; review the institutional and the organizational constraints and to identify the possible remedy of correction methods for the Edwards Aquifer; project the socio-economic impacts and the tradeoffs associated with the different alternative course of actions for the protection of the Edwards underground reservoir; survey the preference ratings of the general public as well as the governing agencies concerning the groundwater pollution vs. the curtail of urban development; identify the best recharge or replenish method for the augmentation of the capacity of the groundwater reservoirs; apply the developed methodology and to analyze the present utilization practice and to compare it with the optimum policies for the Edwards Aquifer in San Antonio, Texas and generalize the developed procedures to become readily adaptable for other metropolitan areas in Texas or the nation.
(*f*) Completed.

148-0410W-810-33

WATERSHED IMPACTS OF RECREATIONAL DEVELOPMENT IN THE GUADALUPE MOUNTAINS NATIONAL PARK, TEXAS

(*b*) OWRT.
(*c*) Dr. Ernest Fish, Dr. Marvin Dvoracek, Texas Tech University, Lubbock, Tex. 79409.
(*e*) Study the relationships among soils, vegetation, parent materials, climate, geomorphic surfaces, topography, and current land use in the Guadalupe Mountains National Park of Southwest Texas, and to relate these factors to the surface and groundwater hydrology, erosion, sedimentation, and chemical water quality; establish, as closely as possible, the changes that have occurred in the past in regard to climate, vegetation, erosion, and surface and groundwater hydrology, and to relate these to the land use history including grazing, road construction, fire, and human culture and to study the changes in vegetation, sedimentation, erosion, and surface and groundwater quality and yield that will occur as this area becomes increasingly developed for recreational land use.

148-0411W-860-33

RESERVOIR EUTROPHICATION: FACTORS GOVERNING PRIMARY PRODUCTION

(*b*) OWRT.
(*c*) Dr. Owen Lind, Baylor University, Waco, Tex. 76703.
(*e*) Determine the relative importance of environmental variables in governing the rate of phytoplankton production in reservoirs; and to provide a quantitative factorial analysis essential for proper reservoir management to retard undesirable cultural eutrophication.

148-11147-840-33

IMPROVED WATER AND NUTRIENT MANAGEMENT THROUGH HIGH-FREQUENCY IRRIGATION

(*b*) OWRT.
(*c*) Dr. Terry Howell.
(*e*) Develop high-frequency irrigation management practices that will conserve water, nutrients, and energy. The high-frequency irrigation systems under study will be sprinkler and trickle (or drip) systems. The specific objectives are as follows: to quantitatively determine plant nutrient requirements for specific crops grown under high-frequency irrigation, under optimum soil-water matric potential control; and to evaluate the impact of high-frequency irrigation on water quality and water and energy consumption.

148-11148-810-33

DESIGN OF URBAN DRAINAGE SYSTEMS FOR DOWNSTREAM FLOOD PLAIN MANAGEMENT

(*b*) OWRT.
(*c*) Mr. Leo Beard, University of Texas, Austin, Texas 78758.
(*e*) Develop procedures and criteria for designing storage and drainage facilities in urban areas to accomplish specified objectives of preventing increase of downstream flooding and/or regulating storm runoff for treatment purposes, as well as providing adequate storm drainage, to assure the integrity of flood plain management and insurance measures for areas within and downstream of urban developments.
(*f*) Completed.

148-11149-840-33

AUTOMATION OF PIVOT SPRINKLER IRRIGATION SYSTEMS TO MORE EFFICIENTLY UTILIZE RAINFALL AND IRRIGATION WATER

(*b*) OWRT.
(*c*) Dr. Charles W. Wendt.
(*e*) Develop an automated pivot sprinkler irrigation system which will turn on and off according to the water needs of crops and will turn off during periods of high wind speeds; test the hypothesis that crops grown under automated pivot sprinkler irrigation systems will require less irrigation water than crops grown under manually operated pivot sprinkler irrigation systems; and test the hypothesis that energy requirements of automated pivot sprinkler irrigation systems will require less energy for operation than manually operated pivot sprinkler irrigation systems.

148-11150-840-33

ECONOMIC FEASIBILITY AND POTENTIAL OF NEW TECHNOLOGY AND IMPROVED MANAGEMENT FOR IRRIGATION IN TEXAS

(*b*) OWRT.
(*c*) Dr. Ronald Lacewell.

(*e*) Apply models developed and availability for the High Plains and Trans-Pecos to analyze economic implications of new technology. Evaluate mobile trickle distribution systems, new crop varieties, night sprinkling of cotton with saline water and effectively designed irrigation wells; modify models available to consider a risk component of yield and price to evaluate and develop optimum irrigation farm management plans for selected levels of risk; and develop drought-agricultural production relationships by production region in Texas and link into models available to estimate the impact on irrigation as well as develop plans to minimize negative social effect of drought.

148-11151-860-33

NETWORK FLOW OPTIMIZATION FOR WATER RESOURCES PLANNING WITH UNCERTAINTIES IN SUPPLY AND DEMAND

(*b*) OWRT.
(*c*) Dr. Paul Jensen, University of Texas, Austin, Texas 78712.
(*e*) Develop computational procedures for determining the optimal flow distribution in a water system. These procedures are to deal with the situation in which inflows and outflows are not known with certainty. Rather flow plans are to be determined which maximize expected benefit less cost when only probability distributions of inflows and outflows are available.

148-11152-860-33

SURVEY AND CONTROL OF SYNTHETIC ORGANICS IN TEXAS WATER SUPPLIES

(*b*) OWRT.
(*c*) Dr. Bill Batchelor.
(*e*) Evaluate the significance of synthetic organic compounds in selected water supplies and to investigate the effectiveness of conventional and nonconventional treatment technology for their control. To achieve this, the following will be pursued: develop and test analytical procedures to characterize contamination by synthetic organics; analyze selected water systems for organic contamination; identify water supplies with specific problems of organic contamination; and conduct laboratory treatability studies to determine the effectiveness of various treatment processes in removing synthetic organics or their precursors.

148-11153-070-33

CONTAMINANT TRANSPORT IN HYDROGEOLOGIC SYSTEMS

(*b*) OWRT.
(*c*) Dr. Donald Reddell.
(*e*) Develop procedures and instrumentation necessary to evaluate dispersivity of unsaturated porous media under field conditions; develop procedures and instrumentation for evaluating dispersivity of saturated porous media under field conditions; and using the dispersivity measurements measured in objectives 1 and 2 in numerical models developed by prior research, compare the predicted contaminant transport and distribution at two field sites with the measured distribution.

148-11154-800-33

ANALYSIS OF WATER RESOURCES REQUIREMENTS FOR THE ENHANCED (TERTIARY) OIL RECOVERY IN THE SOUTHERN PLAINS REGION OF THE U.S.

(*b*) OWRT.
(*c*) Dr. C. S. Shih, University of Texas at San Antonio, San Antonio, Texas 78285.
(*e*) Develop an integrated and practical quantitative analysis procedure based on Bayesian statistics, regression analysis, long range planning methodologies, and resources allocation modeling, coupled with petroleum technology forecasting, for the projection of water resource requirements to support our future enhanced oil recovery operations in the Southern Plains Region; study the technological and financial constraints and to assess potential application of different enhanced oil recovery operations in the Southern Plains Region; project the distribution of enhanced oil operations in the Southern Plains Region and to assess the economic trade-offs associated with different enhanced oil recovery operations versus high quality water resources requirements; optimize the allocation of water resources for competitive demands in the water limiting areas for enhanced oil recovery operations; identify the potential pollution effects upon both the surface and groundwater resources in the region due to the enhanced oil recovery operations; apply the developed methodology and to analyze the water resource requirements associated with the enhanced oil recovery operations for each subregion and to generalize the developed analytical procedures to readily become a utilizable method for future analyses in other oil producing regions in the United States.

148-11155-860-33

FEASIBILITY STUDY TO DETERMINE THE PRACTICALITY OF USING POTABLE MUNICIPAL WATER SUPPLIES AS A SOURCE OF CONDENSER COOLING WATER FOR POWER GENERATING FACILITIES

(*b*) OWRT.
(*c*) Dr. R. H. Ramsey, Texas Tech University, Lubbock, Texas 79409.
(*e*) Determine the probable ranges of temperature gradients existing in the water treatment and municipal distribution systems under different cooling water temperature regimes; determine the effects of elevated water treatment processes; determine the effects on energy consumption when the waste heat remaining in the cooling water is utilized in normal municipal uses; determine the environmental impacts associated with the approach and determine public acceptance of elevated water temperatures in domestic water supplies.

148-11156-870-33

IMPACT OF DISCHARGE FROM POSSUM KINGDOM RESERVOIR (TEXAS) ON GENIC ADAPTATION IN AQUATIC ORGANISMS

(*b*) OWRT.
(*c*) Dr. Earl Zimmerman, North Texas State University, Denton, Texas 76201.
(*e*) Evaluate the impact of hydroelectric generation-related discharge from Possum Kingdom Reservoir in North-Central Texas.

UNIVERSITY OF TEXAS AT AUSTIN, Center for Research in Water Resources, 10,100 Burnet Road, Austin, Tex. 78758. Leo R. Beard, Director.

149-09921-800-33

WATER RESOURCE SYSTEM MANAGEMENT FOR INCREASED POWER PRODUCTION

(*b*) Department of the Interior–Office of Water Research and Technology.
(*d*) Theoretical, applied research, Masters thesis, Doctoral dissertation.
(*e*) Develop technology for determining the optimum integration of a large hydroelectric power system into a predominantly thermal power system, thus producing maximum usable energy and peaking capability. Consideration is given to the seasonal variation of trade-offs with other water resource system functions such as flood control, water supply, recreation, and low-flow regulation. The particular objective is to develop, in coordination with the Corps of Engineers, the Southwestern Power Administration, and the Federal Power Commission, specific operation criteria for 13 major reservoirs and 11 hydropower plants in the Arkansas, Red, White, and Osage River Basins that would maximize the generation of power consistent with other system functions and environmental considerations.
(*f*) Completed.

(*h*) **Optimization Model for the Evaluation of Flood-Control Benefits of Multipurpose Multireservoir Systems,** D. T. Ford, *Center for Research in Water Resources Tech. Rept. Series No. 158*, June 1978. Price: $9.00.
Integrated Operation of Water Resource and Electric Power Systems, S. D. Claure-Pereira, *Center for Research in Water Resources Tech. Rept. Series No. 159*, Aug. 1978. Price: $8.75.
Evaluation of Hydroelectric Energy Benefits for a Preponderantly Thermal Power System, J. E. Castillo, *Center for Research in Water Resources Tech. Rept. Series No. 148*, July 1977. Price: $4.00.

149-09922-810-07

WATER YIELD, FLOOD CONTROL AND SEDIMENTATION EFFECTS OF TRINITY RIVER BASIN SCS STRUCTURE

(*b*) U.S. Department of Agriculture–Soil Conservation Service.
(*d*) Applied research, thesis.
(*e*) Investigators are developing procedures for evaluating the various effects of flood water retarding structures at key locations throughout the Trinity River Basin, emphasizing the effects on the operation of Corps of Engineers reservoirs. Specific objectives are to: review literature and past work relative to such determinations; to develop, test, and apply a computer model for evaluating the combined effects of seepage, evaporation, and transpiration at retarding structures on monthly streamflows at any downstream point, including points downstream of Corps of Engineers reservoirs under various modes of operation of those reservoirs; to develop, test, and apply a computer model for evaluating the effects of seepage at retarding structures and in downstream channels on aquifers; to develop, test, and apply a computer model for evaluating the effects of retarding structures on scour and sediment deposition in downstream channels and reservoirs.
(*f*) Completed.

149-11122-870-68

BEFORE AND AFTER STUDIES ON THE EFFECTS OF THERMAL DISCHARGE INTO LAKE LYNDON B. JOHNSON

(*b*) Lower Colorado River Authority.
(*c*) Phil S. Schmidt, Assoc. Professor of Mechanical Engineering.
(*d*) Field investigation; applied research.
(*e*) This study has been made to obtain reliable temperature, water quality, and biological data "before" and "after" the Lower Colorado River Authority's construction of a generating station on Lake Lyndon B. Johnson. Researchers are also endeavoring to develop, calibrate, and verify computer models by which estimates can be made of the ecological effects of future generating units at this site. The project has been coordinated with quarterly net surveys of the fish population by the Texas Parks and Wildlife Department.
(*f*) Completed.

149-11123-880-60

CALIBRATION AND VALIDATION RESERVOIR ECOLOGICAL MODEL

(*b*) Texas Water Development Board.
(*d*) Field work; applied research.
(*e*) This research was part of a group of studies, sponsored by the Texas Water Development Board (TWDB), that were initiated in response to the Texas Water Code which mandates "the maintenance of a proper ecological environment of the bays and estuaries of Texas and the health of related living marine resources." Implementation of this policy required a knowledge of bay and estuary ecosystems so the TWDB established studies to investigate the effects of freshwater inflows on the bays and estuaries of Texas. Such studies on the Lavaca Bay, San Antonio Bay, and Nueces Bay systems were completed, and attention was directed to two of the remaining bay systems, the Trinity and Colorado River deltas. Studies in the Trinity River and Colorado River delta systems were performed to determine nutrient exchange rates from the marshes of both systems, to investigate the sources and effects of toxic materials in the lower Trinity River and delta, and to provide analytical services for associated studies. Investigators also assisted TWDB personnel in calculating nutrient loadings for each of the bay systems studied in this and previous related projects.
(*f*) Completed.

149-11124-300-10

DETERMINATION OF SKEW COEFFICIENTS FOR SOUTHWESTERN DIVISION AREA

(*b*) U.S. Army Corps of Engineers.
(*d*) Theoretical; design.
(*g*) Investigators developed a prediction equation and an isoline map that can be used for estimating skew coefficients in the statistical analyses of annual peak streamflow within the Southwestern Division of the Corps of Engineers.
(*f*) Completed.

149-11125-800-38

DEVELOP AND DEMONSTRATE PROCEDURES FOR NATIONAL ASSESSMENT OF WATER FOR ENERGY AND OTHER USES

(*b*) U.S. Water Resources Council.
(*d*) Theoretical; design.
(*g*) Investigators for this project developed hydrologic procedures, analyses, and data bases for use in the Water Resources Council's (WRC) Water for Energy program. Information gathered by CRWR researchers assisted WRC in defining the present supply of the nation's surface water resources at the aggregated subarea level of geographic detail. Studies also established a surface water data base that describes present modified flows and water accounting units in which water utilization for energy development is of concern in WRC subregions. The regionalized flow-duration-frequency curves and annual monthly frequency of exceedence curves that were formulated by this project aided WRC in site–specific assessment of water availability for energy development and associated water resources uses. Much of the work on this project was in cooperation with the U.S. Geological Survey.
(*f*) Completed.

149-11126-860-60

EXPANSION OF LAKECO RESERVOIR MODEL

(*b*) Texas Department of Water Resources.
(*c*) Neal E. Armstrong, Professor of Civil Engineering.
(*d*) Theoretical; design.
(*e*) Researchers are expanding the predominantly biological reservoir model LAKECO to include physico-chemical reactions. The interrelationship between chemical and biological variables in reservoirs and lakes is a significant one, but there is yet no reservoir model that combines the biological cycle with a broad range of physical chemical reactions. Current reservoirs and lake models have concentrated on simulating biological variables like algae and important associated inorganic quality parameters such as nitrogen, phosphorus, dissolved oxygen, pH, and temperature. These variables provide a general view of the trophic state, aesthetic quality, and life support capability of the impoundments. However, water quality and its use for domestic, agricultural, and industrial purposes is largely determined by its chemical characteristics. Some of these include alkalinity, hardness, iron, sulfates, silica, and fluorides. The LAKECO model, developed by Water Resources Engineers (WRE) for the U.S. Army Corps of Engineers Hydrologic Engineering Center is being expanded to include more chemical reactions. The six chemical variables selected to be included in the model are calcium (Ca), magnesium (Mg), iron (Fe), sulfate (So_4), and fluoride (Fl). Significant reactions that are like-

ly to occur such as complexation, precipitation, release and adsorption onto sediments and adsorption onto precipitates will be incorporated. In addition, alkalinity and total dissolved solids (TDS) will be converted to non-conservative substances, and oxidation reduction equilibria will be included.

149-11127-730-33

EFFECTIVENESS OF TECHNOLOGY TRANSFER PROGRAMS

(*b*) Office of Water Research and Technology.
(*d*) Theoretical; applied research; for thesis (M.S.).
(*e*) Investigators evaluated the effectiveness of various technology transfer techniques used by The Center for Research in Water Resources and, on the basis of recommendations from a large number and variety of active organizations, formed conclusions concerning the most effective general means or combination of means for transfer of water resources technology between the academic and practicing communities. Such conclusions can be used as guidance for the administration of future research and technology transfer programs that would be particularly relevant to water resources technology. CRWR Technical Report Number 140 is a publication that arose from the studies for this project.
(*f*) Completed.

149-11128-810-13

HYDROLOGIC MODEL DEVELOPMENT FOR TULSA, OKLAHOMA

(*b*) U.S. Army Corps of Engineers.
(*d*) Theoretical; applied research.
(*e*) Recorded runoff data from urbanized areas with terrain and hydrologic characteristics similar to the Tulsa area were collected. Investigators used this information to develop a method to adjust the natural flood flows so that they reflect urban development in the watershed surrounding Tulsa, Oklahoma. Among the data studied runoff hydrographs and information about drainage basin characteristics such as size, streambed length and slope, percent and type of watershed development, stream modification, amount of impervious areas, amount of storm sewers, and land use of underdeveloped portions. The collected data represented watersheds with varying amounts of urban development. Various rainfall-runoff were investigated, and the model selected for maximum utility was calibrated for all areas studied and applied to an urban watershed in the Tulsa metropolitan area for demonstration purposes.
(*f*) Completed.
(*h*) **An Urban Runoff Model for Tulsa, Oklahoma,** L. R. Beard, S. Chang,, *Center for Research in Water Resources Tech. Rept. Series No. 160*, Aug. 1978. Price $7.75.

149-11129-800-10

HYDROLOGICAL IMPLICATIONS OF CLIMATIC CHANGE ON WATER RESOURCE DEVELOPMENT

(*b*) U.S. Army Corps of Engineers, Institute of Water Resources.
(*d*) Theoretical; applied research.
(*e*) Researchers are assessing the hydrological and project operation and maintenance implications of potential climatic change on the U.S. Army Corps of Engineers water resources development and management program. The research is part of a federal program to study climatic fluctuations and their implications and will aid the President in establishing a comprehensive, interagency planning process and public involvement. Several agencies are participating in the study and are developing their own programs and research needs. The Corps of Engineers, with its national involvement in water resources development, needs to make an initial assessment of the potential effects of climatic change on its current and future policy and planning considerations. Appropriate areas of research also need to be suggested. To assist the Corps of Engineers with this project, investigators are assessing the reliability of currently employed tools for hydrologic analysis and forecasting such as deterministic, stochastic, and probabilistic analytical techniques. Researchers are evaluating methods with consideration to perceptible, longer term changes in climate and its variability. They also are assessing the effects and relative impacts of potential climate changes with respect to the range of functional areas of water management and water resources development within the authority of the Corps of Engineers.

149-11130-340-10

HYDRO-POWER POTENTIAL STUDY

(*b*) U.S. Army Corps of Engineers, Hydrologic Engineering Center.
(*d*) Theoretical; applied research.
(*e*) Researchers are aiding the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers with a national assessment of potential hydroelectric power. HEC has been assigned the major analytic work required to develop a rapid and inexpensive method of reliably evaluating the potential of hydroelectric power in terms of energy and to create computer base data files. Investigators are assisting HEC in developing the necessary technology to complete their work. The Center had developed a model for assessing hydroelectric power potential in a river basin that can be modified to HEC's needs and proposed solution procedures. Also, CRWR recently obtained a processed file of daily streamflow records throughout the U.S. from the U.S. Geological Survey. The CRWR hydropower model is being adapted to accept input in the format used in computer program HEC 5-C, to conform to site-selection criteria adopted by HEC, and to provide output needed in the HEC study. Monthly streamflow data and brief documentation are being derived from the daily-streamflow file for about 5,000 stations, and procedures are being developed and applied for establishing the period of most severe droght at each station.

149-11132-490-54

METHODOLOGY TO EVALUATE ALTERNATIVE COASTAL ZONE MANAGEMENT POLICIES: APPLICATION IN THE TEXAS COASTAL ZONE

(*b*) National Science Foundation–Research Applied to National Needs.
(*c*) Joseph F. Malina, Professor of Civil Engineering.
(*d*) Theoretical; applied research.
(*e*) Competing demands for natural resources in the Texas Gulf Coast region caused by increased residential, commercial, and industrial growth require formulation of rational planning guidelines. To fulfill this need, a multidisciplinary team of researchers has, for the past five years, been developing a methodology and operation criteria that will permit the State of Texas to determine environmental and economic impacts of alternative management policies now and in the future.
(*f*) Completed.

149-11133-860-60

A PRE-IMPOUNDMENT INVESTIGATION OF WATER QUALITY CHANGES ASSOCIATED WITH INUNDATION OF THE PALMETTO BEND RESERVOIR

(*b*) Texas Department of Water Resources.
(*c*) Neal Armstrong, Professor of Civil Engineering.
(*d*) Field investigation; applied research.
(*e*) Determine the probable water quality changes (especially dissolved oxygen and nutrients) that will occur in the Palmetto Bend Reservoir during and immediately after iniitial inundation. To achieve this objective, researchers will: (1) determine decomposition rates of terrestrial vegetation (both short and tall) immediately following inundation; (2) determine nutrient exchange rates for carbon, nitrogen, and phosphorus from the soil and decaying vegetation to be inundated and the corresponding increase or decrease in nutrients and dissolved oxygen in the overlying water;

(3) determine suspended solids, carbon, nitrogen, and phosphorus concentrations in the Navidad River (the inundating water) in the reservoir area; (4) determine key ecological parameters for subsequent monitoring and modeling; and (5) prepare a report containing the results and conclusions of the study.

The decomposition rates of various types of vegetation and the nutrient exchange rates from the reservoir vegetation and soils will be determined by studying samples of different plant types taken from the area during fall, winter, and spring. These samples have been placed in reactors, housed in the CRWR environmental chamber, where temperatures are regulated to correspond to actual field temperatures.

The samples have been inundated with water which has been modified chemically to simulate the Navidad River water which is being pumped slowly through the reactors to yield a residence time of about that expected in the reservoir. Samples are taken from the reactor influent and effluent for carbon, nitrogen, phosphorus, and dissolved oxygen analyses. Nutrient exchange rates are being calculated in units of kg $ha^{-1}d^{-1}$ using existing computer programs and techniques.

Decomposition rates are being estimated by suspending, in nylon net containers, leaves and stems of various plants found in the reservoir area. The biomass will be preweighed and then suspended in the net containers in an aquarium seeded with water and soil from the reservoir area. Twenty replicates of each plant type will be used so that containers may be withdrawn periodically, weighed, and examined microscopically. Decreases in weight will determine the decomposition rate that can be expected after inundation.

Model reservoirs with facilities for temperature stratification and multi-depth sampling will also be used to determine vegetation decompostion rates and carbon, nitrogen, and phosphorus exchange rates. Samples of soil with the larger types of vegetation will be removed intact from selected areas within the reservoir area, returned to the laboratory, and placed in the model reservoir in as undisturbed state as possible.

The model reservoirs will be inundated with chemically modified water and a flow-through rate established to provide a residence time approximately equal to that expected in the reservoir. Samples will be taken from various depths of the model reservoirs and analyzed for dissolved oxygen, temperature, pH, suspended and volatile solids, carbon, nitrogen, and phosphorus. These data will be used to determine overall changes in water quality above the inundated terrestrial vegetation and to calculate exchange rates of carbon, nitrogen, and phosphorus from the soil and vegetation.

Samples from the Navidad River will be taken at points in, downstream, and upstream of the reservoir area by Dr. Ernst Davis of the University of Texas School of Public Health in Houston and analyzed in the CRWR laobratory for total organic carbon, nitrogen, phosphorus, and total suspended and volatile suspended solids. Results of these analyses will be used to determine the water quality of the Navidad River and the nutrient flux into the reservoir using data gathered by Dr. Davis on the vegetation types in the inundation area. Dr. Davis is doing a complementary study on the same area with a grant from the Texas Department of Water Resources.

Project investigators will select key ecological parameters for future monitoring and modeling. This will be accomplished by consideration of those variables included in stream and reservoir ecological models and those variables which should be monitored to follow the changes in water quality and organic populations that determine the extent to which the reservoir meets its intended uses.

149-11134-800-54

PROVISION OF ADMINISTRATIVE AND ANALYTICAL SUPPORT FOR WORKING GROUP IN WATER RESOURCES TECHNOLOGY

(*b*) National Science Foundation.
(*c*) Walter L. Moore, Professor of Civil Engineering.
(*d*) Theoretical; applied research.
(*e*) Water resources technology is a topic of active cooperation between the United States and the U.S.S.R. at the government level. In this project the state of technology in the United States and the U.S.S.R. in four specific areas was monitored. These are: (a) water resources planning and management; (b) automation of on-farm application of water; (c) the use of plastic in concrete for water resources construction; and (d) the construction of water resources facilities in extremely cold weather. This project also supported a secretariat which served the committee responsible for the overall management of the water resources research cooperation between the U.S. and the U.S.S.R.
(*f*) Completed.

149-11135-800-33

SOCIAL IMPACTS OF WATER RESOURCES PROJECTS

(*b*) Office of Water Research and Technology.
(*d*) Theoretical; applied research.
(*e*) Investigators are forming practical guidelines to aid in assessing the future environmental, social, and economic impacts that issue from public work projects. They will then suggest a method by which such effects can be integrated into the planning process of similar projects.

There is a need to define the potential impacts of public works within the constraints of certain relevant factors and variables so that society can make rational decisions concerning the implementation of such projects. Some of the various future costs and benefits of public works are maintenance costs, increased resources development costs, increased or decreased environmental management costs, demolition or reconstruction costs, direct benefits for which the project is designed, and indirect benefits and costs that will occur as a result of the project. Before the public commits itself to a public works project, such costs and benefits need consideration. The possibility of future changes in societal values and in technology should also be recognized and incorporated into the evaluations relating to a planned project. A water resource project that has been in existence for several years is being used as a vehicle to formulate a framework for properly assessing the role of social impacts in the water resource planning process. Affected parties are being interviewed, and information will be reviewed by experts in sociology, economics, law, and other disciplines to develop a procedure for identifying and evaluating the social impacts of the project.

149-11136-860-75

STUDIES OF THE EFFECTS OF THE ALTERATION OF FRESHWATER INFLOWS INTO MATAGORDA BAY AREA, TEXAS

(*b*) Espey, Huston and Associates.
(*c*) Neal E. Armstrong, Professor of Civil Engineering.
(*d*) Theoretical; applied research.
(*e*) Investigators are studying the effect of the alteration of freshwater inflow into the Matagorda Bay area of Texas. Like many other principal Texas embayments the Matagorda Bay system has management problems. Municipal and industrial developments impose some stress on the bay, and the use of water upstream in the drainage basin competes with the requirements for sustaining the bay's ecosystem. Other activities may also cause problems. They include: reservoir development in the upper and lower Colorado River Basin; diversion of water from the

Colorado River for such uses as cooling the South Texas Nuclear Plant, lignite mining, irrigation, and other uses; and the construction of the Palmetto Bend reservoir on the Navidad River. In addition to these changes, the development of more industries on the bay periphery and the rivers draining to the bay will cause even further changes which will need study.

149-11137-390-54

THE VALUE OF DATA IN RELATION TO UNCERTAINTY AND RISK

(*b*) National Science Foundation.
(*d*) Theoretical; applied research.
(*e*) Investigators will be developing a theoretical basis for judging the value of increased amounts of data in natural disaster management. As in almost all developmental planning, there is a risk that the actions taken will be either inadequate or too conservative in relation to subsequent events that could not have been predicted or forecasted accurately. In assessing the risk related to natural phenomena such as earthquakes, flood, winds, and tornados, information of the frequency and magnitudes of past observed events is used. Since past events are never perfectly representative of future ones, there is some uncertainty as to the exact risk associated with any particular managment plan. This uncertainty varies inversely with the amount of data used in the estimate. By increasing the data base, uncertainty can be reduced, but risk cannot. This study will attempt to establish generalized criteria for the value of additional data while considering that reducing uncertainty is reducing only one component of the overall risk. The large amount of high-quality streamflow data available for the United States will be used as a primary data base for this study. However, the basic principles developed would also apply to other disaster-related phenomena such as earthquakes, tsunamis, tornadoes, and hurricane winds. The study's results will also be applicable to nonstructural as well as structural management projects.

UNIVERSITY OF TEXAS AT AUSTIN, College of Engineering, Department of Civil Engineering, Austin, Tex. 78712. Joseph F. Malina, Jr., Department Chairman.

151-11138-820-00

STOCHASTIC MODELING OF GROUNDWATER FLOW

(*b*) Bureau of Engineering Research, The University of Texas at Austin.
(*c*) Randall J. Charbeneau, Asst. Professor of Civil Engineering.
(*d*) Theoretical; basic research; Master's or Doctoral theses.
(*e*) Much of the current research in groundwater hydraulics deals with prediction of groundwater flow by deterministic numerical simulation models. To ascertain the role of parameter uncertainty a stochastic Monte Carlo method is being used. Special emphasis is placed on determining the uncertainty in the time of travel, with possible application to dispersion of contaminants.

151-11139-820-00

MODELING GROUNDWATER HYDRAULICS AND CONTAMINANT TRANSPORT

(*b*) Bureau of Engineering Research, The University of Texas at Austin.
(*c*) Randall J. Charbeneau, Asst. Professor of Civil Engineering.
(*d*) Theoretical; applied research; Doctoral thesis.
(*e*) Finite element models for groundwater flow and contaminant transport are being developed. Special emphasis is on flows near wells, dispersion phenomena and the fate of reacting contaminants.

151-11140-810-00

STATE VARIABLE MODELING FOR URBAN WATER RESOURCE SYSTEMS

(*b*) Bureau of Engineering Research, The University of Texas at Austin.
(*c*) Larry W. Mays, Asst. Professor of Civil Engineering.
(*e*) This research was directed at developing models for determining the effects of urbanization on urban water resource systems. Because urban water resource systems consist of many complex interrelated subsystems, the objective of this research was to independently investigate the application of state variable modeling to several of the urban subsystems. State variable models for linear and nonlinear hydrologic systems analysis were developed. In order to determine if and when existing drainage facilities will become inadequate, a sewer network flow routing model based upon state variable modeling was also developed.
(*f*) Completed.

151-11141-810-33

METHODOLOGY FOR ANALYZING EFFECTS OF URBANIZATION ON WATER RESOURCE SYSTEMS

(*c*) Larry W. Mays, Asst. Professor of Civil Engineering.
(*e*) Project focused on the development of a model for analyzing the effect of urbanization on urban water systems, with emphasis on storm drainage systems. becuase of the time variant nature of the hydrology of these systems, the model is based upon the state variable concept of system synthesis, which will enable planners to determine when existing and new urban drainage systems will become inadequate after future urbanization in the particular area. The information provided through this research will also help planners and managers to reduce the cost of urban drainage systems. The need for such a study is evidenced by the new and dynamic hydrologic conditions in areas of rapid urbanization.
(*f*) Completed.

151-11142-870-10

DEVELOPMENT OFA MODEL FOR ANALYZING STORM SEWER SYSTEMS

(*b*) U.S. Army Corps of Engineers, Construction Engineering Research Laboratory.
(*c*) Larry W. Mays, Asst. Professor of Civil Engineering.
(*e*) Develop an algorithm and a computer program for analyzing large storm sewer systems on military installations. Several objectives in developing such a model include the following: develop schemes to compute inflows into systems, develop a routing scheme to describe flows through the system, incorporate all design assumptions and constraints. One of the primary concerns in developing such a model is the capability or methodology of representing an arbitrary multi-level branching sewer system. The program is capable of taking an arbitray list of inputs and translating these into an ordered system or network.
(*f*) Completed.

151-11143-370-00

OPTIMAL RISK BASED DESIGN OF HIGHWAY DRAINAGE CULVERTS

(*b*) Bureau of Engineering Research, The University of Texas at Austin.
(*c*) Larry W. Mays, Asst. Professor of Civil Engineering.
(*e*) Overall objective of this research is to develop an optimal risk-based procedure for the design of highway drainage culverts. Engineering designs are inevitably subject to uncertainties and the design of highway drainage culverts is no exception. These uncertainties, which have related risks, arise in almost every aspect involved in culvert design. They include risks due to hydraulic, hydrologic, construction and cost uncertainties. Unfortunately, traditional design methods use deterministic appproaches which do not account for these uncertainties and related risks.

The objective of this research is to develop a procedure for the design of culverts in which the trade-off between installation costs and expected damages can be properly balanced.

(*f*) Completed.

151-11144-800-54

OPTIMAL RISK BASED DESIGN OF WATER RESOURCES ENGINEERING PROJECTS

(*b*) National Science Foundation.
(*c*) Larry W. Mays, Asst. Professor of Civil Engineering.
(*e*) In the design of water resources engineering projects there are many uncertainties due to the basic randomness in flood and rainfall frequencies. These uncertainties can be classified in four general types, hydrologic, hydraulic, structural, and economic. This research is a theoretical effort to establish a scientific basis for systematically analyzing and incorporating the uncertainties into the evaluation of the overall risk for the optimal design of water resources engineering projects. Theoretical consideration is given to how this overall risk can be incorporated into optimization models.

151-11145-860-60

DEVELOPMENT OF A MODEL FOR PLANNING OPTIMAL WATER REUSE

(*b*) Texas Department of Water Resources.
(*c*) Larry W. Mays, Asst. Professor of Civil Engineering.
(*e*) Research is focused on developing a water reuse planning model to determine the optimum reuse of wastewaters on a regional basis, minimizing the cost of water supply. Wastewaters from all use sectors along with fresh water, are considered as candidate sources or origins of water for other elements within the use sector and also for elements of other use sectors. Another aspect of this research is to determine the best degree of treatment, based upon growth patterns. During the first stage of the research, the scope will be to develop a model for a single period planning. The application of this model will be demonstrated using information for a region in the state of Texas. For the second stage of the research the scope will be to expand the single period model into a model for a multiperiod planning by a capacity expansion approach.

151-11146-800-00

DEVELOPMENT OF A MODEL FOR WATER AND ENERGY SYSTEMS

(*b*) University Research Institute.
(*c*) Larry W. Mays, Asst. Professor of Civil Engineering.
(*e*) Develop a basic screening model for analyzing the interrelated water and energy systems. The model is for the purpose of quantification and optimization of water supplies for energy conversion processes, considering other competing uses such as agriculture. This pahse has been to develop a general mathematical model for the optimization of a single period planning considering three interacting subsystems: the water, the power, and the coal, gas, and oil subsystems. The model is formulated as a nonlinear programming problem for which the generalized reduced gradient method is used to solve the model. A future phase of the work will be to expand the model for a multiplanning period in the framework of a capacity expansion problem.

UTAH STATE UNIVERSITY, Utah Water Research Laboratory and Utah Center for Water Resources Research, Logan, Utah 84322. Dr. L. Douglas James, Director.

152-0418W-810-00

SORPTIVITY: A FEASIBLE CONCEPT FOR INFILTRATION ESTIMATION ON SMALL RANGE AND WATERSHEDS?

(*f*) Completed.
(*g*) Indexing of infiltration curves by model coefficients allows for infiltrometer data from different researchers to be pooled and provides a basis for simulation modeling of infiltration and runoff on small watersheds.
(*H*) **The Philip Equation: A Feasible Model for Infiltration Estimation on Small Rangeland Watersheds?, R. A. Jaynes,** G. F. Gifford, Watershed Science Unit, Utah State University, UMC 52, 149 pages.

152-0419W-840-00

IMPACT OF WATER AND SOILS WITH HIGH SOURCE-SINK POTENTIALS ON IRRIGATION MANAGEMENT IN THE UPPER COLORADO RIVER BASIN

For summary, see Water Resources Research Catalog **11**, 2.0418.

152-0421W-440-00

A MATHEMATICAL HYDRODYNAMIC CIRCULATION MODEL OF GREAT SALT LAKE FOR RESOURCE MANAGEMENT

For summary, see Water Resources Research Catalog **11**, 4.0041.

152-0423W-840-00

THE DEVELOPMENT OF PROCEDURES TO IDENTIFY AND PREDICT THE IMPACT OF MANAGEMENT PRACTICES ON THE SALINITY OF AGRICULTURAL RETURN FLOWS

For summary, see Water Resources Research Catalog **11**, 5.1436.

152-0424W-800-00

ALTERNATIVE ENERGY DEVELOPMENT OPTIONS AND THE IMPACT ON WATER RESOURCES AND SALINITY

For summary, see Water Resources Research Catalog **11**, 6.0048.

152-0425W-800-00

WATER RESOURCE MANAGEMENT ALTERNATIVES FOR HYDROPOWER AND GEOTHERMAL DEVELOPMENT

(*f*) Completed.
(*g*) The report proposes a heat exchanger system design which is capable of utilizing warm and highly mineralized waters, and recommends that the design be constructed and tested on a demonstration basis.
(*h*) **An Energy Accounting Evaluation of Several Alternatives for Hydropower and Geothermal Development,** J. C. Batty, J. P. Riley, W. J. Grenney, D. A. Bell, *PRJER-031-1*, Utah Water Research Laboratory, Logan, Utah 84322.
For summary, see Water Resources Research Catalog **11**, 6.0124.

152-0426W-800-00

DEVELOPMENT OF AN INTERACTIVE PLANNING METHODOLOGY FOR DISPLAYING EFFECTS AND ESTABLISHING PUBLIC PREFERENCE AMONG MULTI-OBJECTIVE WATER RESOURCE PLANS

For summary, see Water Resources Research Catalog **11**, 6.0125.

152-0427W-870-00

A STUDY OF THE OVERALL ENERGY EFFICIENCY OF POLLUTION CONTROL TECHNOLOGIES FOR ENERGY CONVERSION PROCESSES

(*f*) Completed.
(*g*) A mixed integer program was structured to identify the least cost combinations of recycling and treatment alternatives that can be used to control the liquid, solid, and gas waste streams produced from a 750-megawatt coal fired steam electric power plant.

(*h*) **Cost Minimization for Coal Conversion Pollution Control: A Mixed Integer Programming Model,** M. F. Torpy, A. B. Bishop, R. Narayanan, *UWRL water Resources Planning series P-78/001*, Utah Water Research Lahoratory, UMC 82, Logan, Utah 84322.

152-0428W-860-00

INNOVATIONS IN DESIGN OF RURAL DOMESTIC WATER SUPPLY SYSTEMS

(*f*) Completed.
(*g*) Peak instantaneous flow rates in a Utah rural system were measured continuously during two summers on three dead-end lines serving various members of customers.
(*h*) **Rural Domestic Water System Peak Flows and Design Innovations,** T. C. Hughes, Y. Kono, R. V. Canfield, *PRJER-030-3*, Utah Water Research Laboratory, Utah State University, UMC 82, Logan, Utah 84322.

152-0429W-860-00

THE IMPACT OF ENERGY RESOURCE DEVELOPMENT ON UTAH WATER ALLOCATIONS

(*f*) Completed.
(*g*) This research used a linear programming model of the agricultural and energy sectors of Utah to examine the economically efficient allocation of water hetween agriculture and energy.
(*h*) **The Impact of Energy Resource Development on Water Resource Allocations,** J. E. Keith, K. S Turna, S. Padunchai, R. Narayanan, *Waer Resources Planning Series P-78/05*, Utah Water Research Laboratory, Utah State University, UMC 82, Logan, Utah 84322.

152-09076-890-33

FEASIBILITY OF STATE WATER-USE FEES FOR FINANCING WATER DEVELOPMENT AND COST SHARING

(*b*) Office of Water Research and Technology.
(*c*) Dr. Daniel H. Hoggan.
(*d*) Theoretical and field investigation, applied research.
(*e*) As a result of decreasing appropriations of federal funds for water projects in recent years, state and local governments are feeling the pressure to finance a larger share of the costs. One innovative approach to obtaining state funds for water development which appears to have promise is the application of state water-use fees to many or all of the major uses of water. This research project will analyze various use-fee arrangements to determine fund generating potential and feasibility.
(*f*) Completed.
(*g*) Water user fees imposed by a state on major water uses is a possible new alternative source of state water development funds.
(*h*) **A Study of Feasibility of State Water User Fees for Financing Water Development,** D. H. Hoggan, O. W. Asplund, J. C. Andersen, D. G. Houston, *PRWG162-2*, Utah Water Reserch Laboratory, Utah State University, UMC 82, Logan, Utah 84322.

152-09078-860-33

OPTIMIZING CROP PRODUCTION THROUGH CONTROL OF WATER AND SALINITY LEVELS IN THE SOIL

(*b*) U.S. Dept. of the Interior, Office of Water Resources and Technology.
(*c*) Dr. J. Paul Riley, Professor (project coordinator).
(*d*) Theoretical and experimental;applied research for M.S. and Ph.D. theses.
(*e*) Field studies are being conducted to examine the response of crops (in terms of dry matter and grain yield) to root stresses applied at different stages of crop growth. Root stresses are induced through both salinity concentrations in the soil moisture solutions and by soil moisture deficiencies. A model will be developed for general application of the results.
(*f*) Completed.
(*g*) The research deals with hoth domestic and international water prohlems involving crop productiand, namely, the influence of available soil moisture on soil salinity on plant yields.
(*h*) **Optimizing Crop Production through Control of Water and Salinity Levels in the Soil,** I. Steward, et al., *PRWG151-1*, Utah Water Research Lahoratory, Utah State University, UMC 82, Logan, Utah 84322.

152-10149-870-73

USE OF WARM AND/OR SALINE EFFLUENT WATERS FROM ELECTRICAL GENERATING POWER PLANTS FOR FOOD PRODUCTION

(*b*) Utah Power & Light Company.
(*c*) Jay M. Bagley.
(*d*) Field investigation, operation.
(*e*) Explore management techniques for solving some of the problems of power generation and food production simultaneously or in comhination.
(*f*) Discontinued (see 152-10169-840-33).

152-10150-810-60

WATER QUALITY MANAGEMENT ON MOUNTAIN WATERSHEDS

(*b*) State of Utah.
(*c*) E. Joe Middlebrooks.
(*d*) Field investigation, development.
(*e*) Describe and define the impact of recreational development on mountain watersheds in a quantitative sense.
(*f*) Completed.

152-10151-210-70

TESTING A MCNALLY 24" BUTTERFLY VALVE

(*b*) McNally Pittsburg Mfg. Corporation.
(*c*) Calvin G. Clyde.
(*d*) Experiment, operation.
(*e*) Test of a large hutterfly valve will verify its performance prior to its acceptance hy the huyer.
(*f*) Completed.
(*g*) Results sent to sponsor.
(*h*) **Torque and Discharge Calibration of a 24-Inch Diameter McNally/Pittsburgh Valve,** J. P. Tullis, June 1977.

152-10152-890-06

STUDIES TO INVESTIGATE PROPERTIES OF MATERIAL IN PHOSPHATE MINES IN RELATIONSHIP TO OPTIMUM DESIGN OF SPOIL DUMPS

(*b*) U.S. Forest Service.
(*c*) Roland W. Jeppson.
(*d*) Experimental, design.
(*e*) Engineering and nutrient properties will he determined from each separately identifiahle geologic formation constituting the overburden material of the phosphate mines in Southeast Idaho hy lahoratory tests.
(*f*) Completed.
(*g*) The engineering properties of waste spoil from phosphate mines in southeastern Idaho were determined through field and laboratory testing. Based on these properties, the slope stability and settlement characteristics of phosphate spoil dumps were determined.
(*h*) **Engineering Properties and Slope Stability Settlement Analysis Related to Phosphate Mine Spoil Dumps in Southeastern Idaho,** *Hydraulics and Hydrology Series H-78/01*, Utah Water Research Laboratory, Utah State University, UMC 82, Logan, Utah 84322.

152-10153-480-60

EXPERIMENTAL INVESTIGATION OF CLOUD SEEDING POTENTIAL IN WINTER OROGRAPHIC STORMS

(*b*) State of Utah.
(*c*) Geoffrey E. Hill.
(*d*) Field investigation, operation.

(*e*) Cloud seeding material is injected into winter clouds by aircraft upwind of a target area, wherein an instrumented aircraft detects resulting changes.
(*f*) Completed.
(*g*) The work on obtaining precipitation measurements suitable for objective computer processing methods, on making quantitative measurements of supercooled water routinely, on making vertical air motion measurements, and on releasing seeding material from aircraft and measuring in-cloud responses represents primarily a physically based approach to research on cloud seeding efforts.
(*h*) **Research on Increased Precipitation by Cloud Seeding: Development Phase,** *Atmospheric water Resources A-78/03*, Utah Water Research Laboratory, Utah State University, UMC 82, Logan, Utah 84322.

152-10154-480-60

CLIMATOLOGY OF HAILSTORMS IN UTAH–THE HAIL SUPPRESSION POTENTIAL BY CLOUD SEEDING

(*b*) State of Utah/Division of Water Resources.
(*c*) Kenneth G. Hubbard.
(*d*) Experimental, development.
(*e*) Identify and analyze the climatology of Utah hailstorms as a means of determining the potential for hail suppression through the use of cloud seeding.
(*f*) Completed.
(*g*) Hail damage in Utah was examined for individual counties and the entire state. A survey of informal observers was taken and the resulting data base was analyzed. Data from the National Weather Service was also examined. County hail damage figures average four to five percent of production and ranking of counties according to dollar damage occurs in only four of the 29 counties. In many cases, the highest dollar damage occurred in the counties of greatest production which leads to the overall conclusion that the areas of highest dollar damage should receive the greatest concentration of hail suppression effort.
(*h*) **Climatology of Hailstorms in Utah–The Hail Suppression Potential by Cloud Seeding,** K. G. Hubbard, *Final Report*, Apr. 1977, Utah Water Research Laboratory, Utah State University, UMC 82, Logan, Utah 84322.

152-10155-480-06

COOPERATIVE DATA SYSTEM

(*b*) USDA/Wasatch National Forest Service.
(*c*) Duane G Chadwick.
(*d*) Field investigation, data collection.
(*e*) Gather data on wind energy and related parameters.

152-10156-860-60

EVALUATION OF CONSTRAINING ELEMENTS IN MAKING WATER USE CHANGES

(*b*) State of Utah/Division of Water Rights.
(*c*) Jay M. Bagley.
(*d*) Theoretical, development.
(*e*) A guide, based on a systematic consideration of the factors involved in any change from one water use to another, will be developed for administrators who make decisions about water change use applications.

152-10157-870-36

SEPARATION OF ALGAE CELLS FROM WASTEWATER LAGOON EFFLUENTS

(*b*) Environmental Protection Agency.
(*c*) E. J. Middlebrooks.
(*d*) Experimental, development.
(*e*) Develop a practical, reliable, cost-effective method for the removal and disposal of algae cells from waste stabilization lagoon effluents.
(*f*) Completed.
(*h*) **Evaluation of Existing Intermittent Sand Filtration of Wastewater Lagoons,** J. S. Russell, E. J. Middlebrooks, U. S. Environmental Protection Agency.

152-10158-860-60

THE BIOLOGICAL ROLE OF SPECIFIC ORGANIC COMPOUNDS IN AQUATIC ECOSYSTEMS PRODUCED BY OIL SHALE DEVELOPMENT

(*b*) State of Utah.
(*c*) V. Dean Adams.
(*d*) Experimental, operation.
(*e*) Evaluate the biological role of specific organic compounds and the effects of salinity on the stream biota in the Colorado River Basin.

152-10159-860-60

HYDROLOGIC AND WATER QUALITY IMPACTS OF CONSERVATION MEASURES ON UTAH RIVER BASINS

(*b*) State of Utah.
(*c*) Eugene K. Israelsen.
(*d*) Experimental, operation.
(*e*) Estimate the distribution of water quantity and quality in time and space resulting from implemented conservation measures in Utah river basins.

152-10160-820-60

GROUNDWATER MANAGEMENT ALTERNATIVES FOR UTAH: AN ECONOMIC ANALYSIS

(*b*) State of Utah.
(*c*) John E. Keith.
(*d*) Theoretical, development.
(*e*) Economic analysis of the current groundwater use restriction and of various legal-institutional controls.

152-10161-870-60

MANAGEMENT ALTERNATIVES FOR LIVESTOCK WASTE RUNOFF CONTROL IN UTAH

(*b*) State of Utah.
(*c*) James H. Reynolds.
(*d*) Experimental, operation.
(*e*) Identify and quantify the impact of animal feedlot runoff on the water quality of Cache Valley, specifically; and of the State of Utah in general.

152-10162-870-60

RESIDUAL HEAVY METAL REMOVAL BY A WASTEWATER GROWN ALGAE-INTERMITTENT SAND FILTRATION SYSTEM

(*b*) State of Utah.
(*c*) Daniel S. Filip.
(*d*) Field investigation, operation.
(*e*) Feasibility of using phytoplanktonic algae to incorporate heavy metals from wastewater for subsequent removal by intermittent sand filtration.
(*f*) Completed.
(*g*) The technical feasibility of removing certain heavy metals from waste water using algae growing in the lagoons was established.
(*h*) **Residual Heavy Metal Removal by an Algae-Intermittent Sand Filtration System,** D. S. Filip, *WA40/1*, Utah Water Research Laboratory, Utah State University, UMC 82, Logan, Utah 84322.

152-10164-480-60

EXPERIMENTAL WEATHER MODIFICATION

(*b*) State of Utah/Division of Water Resources.
(*c*) Geoffrey E. Hill.
(*d*) Field investigation, development.
(*e*) What meteorological conditions are most suitable for increasing precipitation by cloud seeding. Precipitation amounts received during seeded storms are compared (by use of a numerical prediction model) with amounts expected if seeding were not done.
(*f*) Completed.

152-10165-860-60

DEVELOPMENT OF A CONSUMPTIVE WATER USE MAP FOR UTAH

(*b*) State of Utah/Division of Water Rights.
(*c*) A Leon Huber.
(*d*) Experimental, design.
(*e*) Develop a better understanding of consumptive water use and will prepare maps which present the information in an easily usable form.
(*f*) Completed.

152-10166-870-33

OVERLAND FLOW AND SPRAY IRRIGATION TO UPGRADE WASTEWATER LAGOON EFFLUENT

(*b*) Office of Water Research and Technology.
(*c*) Daniel S. Filip.
(*d*) Field investigation, operation.
(*e*) Compare and evaluate overland flow and spray irrigation as final upgrading processes for municipal wastewater lagoon effluent.
(*f*) Completed.
(*g*) Overland flow could be used as a nitrification-dentrification process if land costs were sufficiently low. The slow rate system can be an excellent tertiary treatment method if the groundwater is protected and no subsurface water collection and discharge is required.
(*h*) **Evaluation and Comparison of Overland Flow and Slow Rate Systems to Upgrade Secondary Wastewater Lagoon Effluent,** M. C. Kemp, D. S. Filip, D. B. George, *Water Quality Series UWRL Q-78/02*, Utah Water Research Laboratory, Utah State University, UMC 82, Logan, Utah 84322.

152-10167-810-33

HYDROLOGIC IMPACT OF GRAZING SYSTEMS ON INFILTRATION AND RUNOFF: DEVELOPMENT OF A MODEL

(*b*) Office of Water Research and Technology.
(*c*) Gerald F. Gifford.
(*d*) Field investigation, operation.
(*e*) Synthesizing from literature all available information regarding impacts of grazing on infiltration and runoff.
(*f*) Completed.
(*g*) Background, development, usage, cautions, and future research needs are given.
(*h*) **Hydrologic Impact of Grazing Systems on Infiltration and Runoff: Development of a Model,** G. F. Gifford, R. H. Hawkins, *Hydrology and Hydraulics Series UWRL/H-79/01*, Utah Water Research Laboratory, Utah State University, UMC 82, Logan, Utah 84322.

152-10168-630-33

A COST-EFFECTIVE SOLAR-POWERED WATER PUMP

(*b*) Office of Water Research and Technology.
(*c*) Duane G. Chadwick.
(*d*) Experimental, operation.
(*e*) Perfect a prototype solar-powered water pump now in existence which will be cost effective for use on small farms having a nearby groundwater or surface water supply that requires moderate lifting.

152-10169-840-33

POTENTIAL FOR USING WASTE WATER FROM ELECTRICAL POWER PLANTS FOR IRRIGATION

(*b*) Office of Water Research and Technology.
(*c*) R. John Hanks.
(*d*) Field investigation, operation.
(*e*) Possibility of using wastewater from electrical power plants in a productive way–as an irrigation water supply.
(*f*) Completed.
(*g*) Based on two years of field data collected, it appears feasible to use the saline wastewater from the plant for irrigation for several years. When excessive soil salinity will develop is not predictable from present knowledge.
(*h*) **Potential for Using Saline Waste Water from Electrical Power Plants for Irrigation,** R. J. Hanks, R. F. Nielson, R. L. Cartee, S. E. Ging, P. McNeil, L. S. Willardson, *Utah Agricultural Experiment Station Bulletin 504*, Utah State University, UMC 48, Logan, Utah 84322.

152-10170-860-33

A CHEMICAL MODEL OF HEAVY METALS IN THE GREAT SALT LAKE

(*b*) Office of Water Research and Technology.
(*c*) J. J. Jurinak.
(*d*) Basic research, theoretical.
(*e*) Formulation and validation of a thermodynamic model to define the natural physico-chemical processes that control the solubility of heavy metals in Great Salt Lake brine.
(*f*) Completed.
(*g*) The model was applied to predict the solubility of copper, lead, cadmium and zinc in samples taken from the north arm of the Great Salt Lake, Utah.
(*h*) **A Chemical Model of Heavy Metals in the Great Salt Lake,** A. E. Van Luik, J. J. Jurinak, *Utah Agricultural Experiment Station Research Report 34*, Utah State University, UMC 48, Logan, Utah 84322.

152-10171-860-33

ESTIMATING THE UNCERTAINTY ASSOCIATED WITH PREDICTED SALINITY LEVELS IN THE UPPER COLORADO RIVER BASIN

(*b*) Office of Water Research and Technology.
(*c*) William J. Grenney.
(*d*) Basic research, theoretical.
(*e*) Estimate the statistical uncertainty associated with predicting future salinity levels in the Upper Colorado River Basin.
(*f*) Completed.
(*g*) This report demonstrates the feasibility of applying stochastic techniques to linear water quality models.
(*h*) **Stochastic Analysis for Water Quality,** R. F. Malone, D. S. Bowles, W. J. Grenney, M. P. Windham, *Water Quality Series Q-79/01*, Utah Water Research Laboratory, Utah State University, UMC 82, Logan, Utah 84322.

152-10172-870-33

INVESTIGATIONS OF VIRUS REMOVAL FROM WATER WITH AN EVALUATION OF A NEW VIRUS DETECTION PROCEDURE

(*b*) Office of Water Research and Technology.
(*c*) Rex S. Spendlove.
(*d*) Experimental, development.
(*e*) Evaluate virus removal and inactivation capability of sand filters used in water treatment. Determine the chlorination inactivation rates of two model viruses in water of selected quality. Determine *in situ* kinetics for virus inactivation in sewage lagoons and fresh water sources. Evaluate the fluorescent virus precipitin test for use in routine screening of water and wastewater for enteric viruses. Determine the potential use of reovirus as a standard in water studies.

152-10173-860-33

VULNERABILITY OF WATER SUPPLY SYSTEMS TO DROUGHTS

(*b*) Office of Water Research and Technology.
(*c*) David S. Bowles.
(*d*) Experimental, development.
(*e*) A drought severity index will be developed to describe the state of a drought as it affects beneficial uses of water. This index will be useful as a basis for 1) assessing the relative vulnerability to drought of water supply systems; 2) prioritizing the use of funds for reducing drought vulnerability of different water management alternatives; and 3) allocating water to drought susceptible communities and other water users.

152-10174-860-33

SALINITY MANAGEMENT OPTIONS FOR THE COLORADO RIVER

(*b*) Office of Water Research and Technology (regional project–Colorado State University, BLM, University of California-Riverside, University of Arizona).
(*c*) Jay C. Andersen.
(*d*) Experimental, design.
(*e*) Designed to aid local, state and federal agencies in ameliorating the salinity problem of the Colorado River.
(*f*) Completed.
(*g*) Control costs were estimated with a physical model developed to predict the response of soil, water, and crop factors. Input-output models were used to estimate indirect economic impacts.
(*h*) **Salinity Management Options for the Colorado River,** J. C. Andersen, et al, *Water Resources Planning Series P-78/03*, Utah Water Research Laboratory, Utah State University, UMC 82, Logan, Utah 84322.

152-10175-800-33

OPTIMIZATION OF WATER RESOURCES SYSTEMS USING INTERACTIVE INTEGER PROGRAMMING-SIMULATION MODELS

(*b*) Office of Water Research and Technology.
(*c*) William J. Grenney.
(*d*) Theoretical, design.
(*e*) Develop and apply integer optimization and simulation modeling to two important dimensions of water resources management problems.
(*f*) Completed.
(*g*) A systems analysis methodology is presented for identifying the least cost combination of municipal water supply facilities and operating rules.
(*h*) **An Integer Programming Methodology for Municipal/Regional Water Supply Planning,** T. C. Hughes, P. E. Pugner, C. G. clyde, *PRWG198-2*, Utah Water Research Laboratory, Utah State University, UMC 82, Logan, Utah 84322.

152-10176-800-33

STOCHASTIC MODELING OF WATER SURFACE ELEVATIONS FOR TERMINAL LAKES

(*b*) Office of Water Research and Technology/State of Utah.
(*c*) L. Douglas James.
(*d*) Experimental, design.
(*e*) A technique for establishing the frequency distribution of terminal lake stages at different time horizones will be developed.
(*f*) Completed.
(*g*) Data on damages to 21 cost centers were collected, and a damage simulation model was developed to use them to estimate average annual damages under current conditions and benefits from lake level control efforts. Average annual damages to the mineral industry, railroads, highway, wetlands, and other properties were estimated to be currently $1,550,000.
(*h*) **Estimation of Water Surface Elevation Probabilities and Associated Damages for the Great Salt Lake,** L. D. James, D. S. Bowles, W. R. James, R. V. Canfield, *Water Resources Planning Series P-79/03*. Utah Water Research Laboratory, Utah State University, UMC 82, Logan, Utah 84322.

152-10177-860-33

IDENTIFICATION OF PRESUMPTIVE CARCINOGENIC COMPOUNDS RELEASED TO WATER SUPPLIES BY OIL SHALE

(*b*) Office of Water Research and Technology/State of Utah.
(*c*) V. Dean Adams.
(*d*) Field investigation, operation.
(*e*) Determine the potential mutagenic and carcinogenic hazards posed by the development of oil shale in Utah, Wyoming, and Colorado.

152-11557-860-33

WATER REQUIREMENTS AND POLLUTION POTENTIAL OF GAS PRODUCTION FROM LIGNITE SHALE AND OTHER CARBON SOURCES

(*b*) Office of Water Research and Technology.
(*c*) Daniel S. Filip.
(*d*) Experimental, basic research, thesis.
(*e*) Lignite shale is very plentiful in the State of Utah, but it has not been processed because of its relatively low carbon content. Gasification may be used to extract much of this, now unused, energy, but the water research requirements and pollution potential from this steam-requiring process must first be determined to insure prudent development of this resource in the near future.

152-11558-860-33

CALCIUM CARBONATE PRECIPITATION IN STREAMS AS CONTROLLED BY PHYSICAL-BIOLOGICAL REACTIONS

(*b*) Office of Water Research and Technology.
(*c*) Donald B. Porcella.
(*d*) Experimental, basic research, thesis.
(*e*) Understanding of $CaCO_3$ precipitation in streams may lead to management alternatives by controlling salinity in irrigation waters in the Colorado River Basin. This would result in considerable cost savings to agriculture in the Colorado River Basin, up to $250,000 per extra mg/l of total dissolved solids to irrigators in Imperial Valley.

152-11559-860-33

SALT RELEASE FROM SUSPENDED SEDIMENTS: A SIMULATION MODEL

(*b*) Office of Water Research and Technology.
(*c*) J. J. Jurinak.
(*d*) Theoretical, basic research.
(*e*) This project will develop a simulation model of the physico-chemical processes involved in salt release from transported suspended sediments. The importance of this diffuse source of salinity in the total salt load of a stream has not been addressed. In the Upper Colorado River Basin, this question must be resolved before salinity control measures can be evaluated.

152-11560-810-33

MANAGEMENT OF THE HYDROLOGIC SYSTEM IN AREAS SUBJECT TO COAL MINING ACTIVITES

(*b*) Office of Water Research and Technology/Utah Division of Water Resources.
(*c*) J. Paul Riley.
(*d*) Theoretical, basic research.
(*e*) The project will identify and define the potential benefits in terms of water supply quantities and water quality (salinity and sediment loads) from coal mining activities. The research efforts will be directed towards examining those mining techniques and management practices which will create various possible hydrologic opportunities.

152-11561-340-33

AN EVALUATION OF TRADE OFFS AMONG WATER USE, AIR QUALITY, AND ECONOMIC COSTS IN POWER PLANT SITING

(*b*) Office of Water Research and Technology.
(*c*) John E. Keith.
(*d*) Theoretical, basic research.
(*e*) This project will examine the effects on economic costs and water allocations of power plant siting alternatives necessitated by air quality standards. Water planners will benefit from this study in that the trade-offs between air quality and other uses can be examined.

152-11562-800-33

OPERATING INTERACTIONS BETWEEN MULTI-PURPOSE WATER DISTRICTS AND OTHER GOVERNMENTAL IN-

STITUTIONS IN THE FORMATION AND IMPLEMENTATION OF LAND AND WATER POLICY AND PROGRAMS IN URBANIZING AREAS

(*b*) Office of Water Research and Technology/UWRL.
(*c*) Jay M. Bagley.
(*d*) Theoretical, basic research.
(*e*) The interaction of older and more predominant water supply institutions and other institutions responsible for comprehensive land and water planning and management needs to be analyzed in terms of how well activities and policies harmonize. Specific recommendations for legislative/administrative changes will lead to improved operating effectiveness.

152-11563-800-33

ENERGY ACCOUNTING AS A TOOL FOR EVALUATING MAN-MADE WATER RECREATION

(*b*) Office of Water Research and Technology/USDI.
(*c*) J. Clair Batty.
(*d*) Theoretical, basic research.
(*e*) The research will study the extent to which energy accounting can effectively complement or supplement economic benefit/cost analysis in assessing management alternatives for man-made water recreation facilities. The study will specifically attempt to address the question: Would supplementing the nation's system of any large water recreation facilities by many smaller facilities closer to population centers result in significant reductions of energy use?

152-11564-860-33

IN-CHANNEL SALT-SEDIMENT RELATIONSHIPS IN THE COLORADO RIVER BASIN

(*b*) Office of Water Research and Technology/UWRL.
(*c*) David S. Bowles.
(*d*) Theoretical, basic research.
(*e*) This research is designed to yield mathematical relationships that will describe 1) the interaction between dissolved salts and constituent salt associated with the suspended sediments, 2) the rate of formation of efflorescence, and 3) the salinty contributions from the channel beds and banks.

152-11565-310-33

ESTIMATION OF FLOODS WHEN RUNOFF ORIGINATES FROM DIFFERENT SOURCES

(*b*) OWRT/Department of Computer Science, USU.
(*c*) Ronald V. Canfield.
(*d*) Theoretical, basic research.
(*e*) Flood control requires precise knowledge of the distribution of flood height. The problem of determining this distribution when the runoff originates from nonhomogeneous sources has never been solved. Runoff may be due to spring rains, snowmelt, hurricanes, tropical storms, etc., each of which may have a different distribution of flood height.

152-11566-870-33

ASPEN TO CONIFER SUCCESSION: A PROCESS AGGRAVATING THE SALT POLLUTION PROBLEM IN THE COLORADO RIVER BASIN

(*b*) OWRT/Department of Range Science, USU.
(*c*) Gerald F. Gifford.
(*d*) Field investigation, applied research.
(*e*) This project will provide land managers and practicing field hydrologists some guidelines for adjusting measured field infiltration rates to account for differences in drop size, raindrop fall velocities, soil texture, slope, and compaction effect to enhance the widespread utility of data gathered with a variety of rainfall simulators under something other than ideal conditions.

152-11567-840-33

PREDICTING CROP PRODUCTION AS A FUNCTION OF DROUGHT AND SALINITY STRESS UNDER IRRIGATION

(*b*) OWRT/States of Utah, Colorado, California, and Arizona.
(*c*) J. Paul Riley.
(*d*) Field investigation, basic research.
(*e*) This research will formulate and test models for predicting production functions of crops under drought and salinity stress when irrigation is limited. Thus, these models can be used to predict drought and salinity effects on crop production at other locations and times than when the research was done.

152-11568-850-33

DEFINING STREAM FISH MICROHABITAT REQUIREMENTS FOR WATER PROJECT PLANNING

(*b*) OWRT/Department of Wildlife Resources, USU.
(*c*) William T. Helm.
(*d*) Field investigation, basic research.
(*e*) This project will compare actual brown trout distribution in streams with the microhabitat features of the streams, as a test of the validity of the grouping of habitat features. Validation should permit use of this newly developed quantitative description of trout habitat in planning and designing water-related projects to preserve or restore valuable environmental features necessary for good trout populations.

152-11569-860-33

THE EFFECT OF RISK OF DROUGHT ON ENERGY DEVELOPMENT AND WATER ALLOCATIONS: A PROGRAMMING MODEL FOR UTAH

(*b*) OWRT/Utah Agricultural Experiment Station, USU.
(*c*) Theoretical, basic research.
(*e*) This project will examine the effects of water variability, including drought episodes, on the economically efficient water allocations. The results should provide water planners and administrators with information on probable water demands and optimal water allocations as energy development occurs.

152-11570-860-33

EFFICIENT ALLOCATION OF WATER BETWEEN AGRICULTURE AND ENERGY THROUGH OPTIMUM TECHNIQUES OF WATER USE AND CONSERVATION

(*b*) OWRT/UWRL.
(*c*) R. Narayanan.
(*d*) Theoretical, basic research.
(*e*) Water conservation and efficient use practices in agriculture releases water which can be used to meet growing demand from the energy sector. The net benefits from better water-use technologies are estimated in several hundred million dollars in only the upper Colorado River Basin. The study will provide a basis for allocation decisions under conditions of uncertainty through efficient water use.

152-11571-860-33

USE OF SALINE WATER IN ENERGY DEVELOPMENT

(*b*) OWRT/UWRL.
(*c*) C. Earl Israelsen.
(*d*) Theoretical, development.
(*e*) Most of the energy reserves of the West are located in semi-arid areas where water supplies are already overappropriated. However, there are often large quantities of saline or brackish water located in the proximity of these energy reserves. This study will explore possible ways of converting these sources of low quality water from environmental liabilities to economic assets.

152-11572-800-33

INDEX CONSTRUCTION FOR CONJUNCTIVE WATER AND LAND MANAGEMENT: A PROCESS TESTED ON A HIGH MOUNTAIN WATERSHED

(*b*) OWRT/UWRL.
(*c*) L. Douglas James.
(*d*) Field investigation, operation.
(*e*) The plan of the project is to integrate concepts from the environmental (ecological maturity) and social (human well-being) sciences with economic criteria in planning land and related water use for high mountain watersheds.
(*h*) **Proceedings of a Workshop on Index Construction for Use in High Mountain Watershed Management,** L. D. James, Editor, *General Series UWRL/G-79/01*, Utah Water Research Laboratory, Utah State University, UMC 82, Logan, Utah 84322.

152-11573-800-60

REEXAMINATION OF THE RELATION AND ROLE BETWEEN STATE AND LOCAL AGENCIES CONCERNED WITH WATER SUPPLY AND WITH WATER QUALITY PLANNING

(*b*) State of Utah.
(*c*) Jay M. Bagley.
(*d*) Theoretical, development.
(*e*) This research will develop a set of recommendations effecting integration/coordination of water resources and water quality planning and management programs in the Utah state government.

152-11574-860-60

CRITERIA FOR ACHIEVING AN EQUITABLE BALANCE BETWEEN UPSTREAM AND DOWNSTREAM WATER RIGHTS ON WATER SAVED BY INCREASED WATER USE EFFICIENCY

(*b*) State of Utah
(*c*) R. Narayanan.
(*d*) Theoretical, basic research.
(*e*) Alternative policy implication of equity considerations in allocating water conserved among users will be analyzed to provide trade-offs between economic efficiency and distributional goals.

152-11575-870-60

USE OF GRANULAR MEDIA FILTERS FOR REMOVAL OF ENTERIC VIRUSES FROM SECONDARY WASTEWATER TREATMENT PLANT EFFLUENTS

(*b*) State of Utah.
(*c*) Dennis B. George.
(*d*) Experimental, applied research.
(*e*) The research is concerned with determining the ability of graular media filters to remove and inactivate enteric viruses from municipal wastewater.

152-11576-860-60

DETERMINATION OF THE EFFECTS OF SHIFTS IN WATER USE FROM AGRICULTURE TO COOLING FOR THERMAL ELECTRIC POWER PLANTS ON SALINITY OF THE COLORADO RIVER

(*b*) State of Utah.
(*c*) Jay M. Bagley.
(*d*) Theoretical, basic research.
(*e*) This study will examine the salinity implications from water use options that involve shifting water from agriculture to energy production.

152-11577-810-60

DEVELOPMENT OF A HYDROLOGIC DATA BANK FOR UTAH

(*b*) State of Utah.
(*c*) A. Leon Huber.
(*d*) Experimental, development.
(*e*) Operating procedures and system program specifications will become the basis for a comprehensive data base system of which computer algorithms will be acquired/developed to manipulte numerical type hydrologic and climatologic data files along with documentation and a user's manual.

152-11578-860-60

OVERCOMING INSTITUTIONAL IMPEDIMENTS TO MORE EFFICIENT WATER USE

(*b*) State of Utah
(*c*) Jay M. Bagley.
(*d*) Theoretical, basic research.
(*e*) This research will investigate the institutional implications of making water supply system improvements in a selected river basin–the Weber River Basin–in Utah.

152-11579-820-60

MINIMIZING GROUNDWATER CONTAMINATION ALONG BASIN MARGINS IN THE ARID WEST–PHASE I: ALLUVIAL FANS, BACKGROUND SURVEY, AND SYSTEM DEFINITION

(*b*) State of Utah.
(*c*) Calvin G. Clyde.
(*d*) Experimental, basic research.
(*e*) The problems of recharge and contamination of basin-margin aquifers will be identified and study sites selected as a prelude to later phases.

152-11580-860-60

ASSESSMENT OF CHLORINATED HYDROCARBONS AS PRODUCED BY CHLORINATION IN UTAH AND NATIONAL WATER AND WASTEWATER OZONATION AS AN ALTERNATIVE TO CHLORINATION

(*b*) State of Utah.
(*c*) V. Dean Adams.
(*d*) Experimental, applied research.
(*e*) This research will evaluate selected public drinking water supplies in Utah as to the levels of chlorinated organics with particular emphasis on the trihalomethanes (THM).

152-11581-870-60

EVALUATION OF SLOPED ROCK-GRASS FILTRATION AND COMPARISON WITH OVERLAND FLOW AS A TREATMENT FOR WASTEWATER EFFLUENT

(*b*) State of Utah.
(*c*) Daniel S. Filip.
(*d*) Field investigation, operation.
(*e*) The cost effectiveness and increased efficiency of sloped rock-grass filtration will be reflected by routine analysis for solids, oxygen demands, and nutrient levels at all phases of treatment.

152-11582-390-60

FEASIBILITY OF USING GLAUBERS SALT FOR EFFICIENTLY STORING SOLAR ENERGY

(*b*) State of Utah.
(*c*) Duane G. Chadwick.
(*d*) Experimental, basic research.
(*e*) This research involves laboratory and prototype models using Glauber's salt and other enteric materials for storing solar energy more efficiently and economically than is presently possible using rocks or water.

152–11583–860–60

THE IMPACTS OF URBANIZATION ON WATER USE, COMMUNITY WATER MANAGEMENT AND WATER RIGHTS

(*b*) State of Utah.
(*c*) J. Paul Riley.
(*d*) Theoretical, basic research.
(*e*) This study will make a detailed analysis of how water needs and uses change with urbanization for the purpose

of providing information useful in planning and formulating water management policy.

152-11584-860-31

THE IN-CHANNEL PROCESSES WHICH CONTRIBUTE TO THE SALINITY OF THE PRICE RIVER, UTAH

(*b*) U.S. Bureau of Reclamation.
(*c*) J. Paul Riley.
(*d*) Field experiment, basic research.
(*e*) This project is providing an increased understanding of both natural and man-induced processes which contribute to the salinity of the Colorado River.

152-11585-870-60

IMPACTS OF WATER QUALITY DISCHARGE PERMIT PROGRAMS ON WATER RIGHTS ADMINISTRATION

(*b*) Utah Division of Water Rights.
(*c*) Jay M. Bagley.
(*d*) Theoretical, operation.
(*f*) Completed.

152-11586-870-36

ASSESSMENT OF THE LONG-TERM EFFECTS OF APPLYING DOMESTIC WASTEWATERS TO THE LAND

(*b*) U.S. Environmental Protection Agency.
(*c*) James H. Reynolds.
(*d*) Field experiment, operation.
(*e*) This study was conducted to determine the long-term effects of applying wastewater to the land.
(*f*) Completed.

152-11587-210-88

COLLECTING AND EVALUATING PROTOTYPE DATA IN A PIPELINE SYSTEM

(*b*) Colorado State University.
(*c*) J. Paul Tullis.
(*d*) Experimental, operation.
(*e*) This research is designed to obtain information on how rapidly and under what conditions air comes out of solution and its influence on over-pressurization.

152-11588-350-75

MODEL TESTING OF SPILLWAY FOR NORTH POWDER RIVER PROJECT

(*b*) CH2M Hill.
(*c*) Calvin G. Clyde.
(*d*) Experiment, design.
(*e*) Model testing to evaluate various design alternatives and provide data so as to help make the completed project as safe, economical and efficient as possible.
(*f*) Completed.

152-11589-130-82

INSTRUMENTATION DEVELOPMENT FOR MEASURING TWO-PHASE MASS FLOW

(*b*) Electrical Power Research Institute.
(*c*) J. Paul Tullis.
(*d*) Experimental, development.
(*e*) This research will develop a meter which will measure mass flow when a mixture of air and water flows through a pipeline.

152-11590-220-88

EROSION CONTROL DURING HIGHWAY CONSTRUCTION

(*b*) Transportation Research Board.
(*c*) C. Earl Israelsen.
(*d*) Experiment, development.
(*f*) Completed.
(*g*) This research provides a way of predicting the quantities of erosion that may be anticipated from construction activities and of determining the magnitude of the control effort that needs to be applied to minimize erosion effects.
(*h*) **Manual of Erosion Control Principles and Practices,** C. E. Israelsen, *Hydraulics and Hydrology Series Report H-78/002*, Utah Water Research Laboratory, Utah State University, UMC 82, Logan, Utah 84322.

152-11591-710-00

SOLID STATE DIGITAL RECORDING DEVICE FOR REAL TIME DATA COLLECTION

(*c*) Duard S. Woffinden.
(*d*) Experiment, design.
(*e*) The development of a digital recording system which will record data on a real time basis as it is collected and then play it back directly into a computer without any manual steps.

152-11592-440-00

GREAT SALT LAKE POTENTIAL AS A COLLECTOR OF SOLAR ENERGY

(*c*) J. Paul Riley.
(*d*) Theoretical, basic research.
(*e*) This research will begin the exploratory investigation into the energy producing potential of the Great Salt Lake needed to define the studies required to determine the feasibility of extracting solar energy.

152-11593-860-60

UTAH'S 1977 DROUGHT

(*b*) Utah Division of Water Resources.
(*c*) Trevor C. Hughes.
(*d*) Theoretical, basic research.
(*e*) Document the impact of the drought, describe the drought relief measures, and to assess which proved effective and which not.
(*f*) Completed.
(*g*) Drought impacts upon several sectors of the economy plus the extensive responses of all levels of government in the form of drought relief programs are described and quantified.
(*h*) **Utah's 1977 Drought,** T. C. Hughes, C. Bigler, J. Olds, R. Griffin, E. A. Richardson, L. D. James, N. Stenquist, J. Harvey, *Water Resources Planning Series UWRL/P-78/07*, Utah Water Research Laboratory, Uta State University, UMC 82, Logan, Utah 84322.

152-11594-810-310

DESIGN IMPROVED SEEDING CRITERIA

(*b*) U.S. Bureau of Reclamation/Utah Division of Water Resources.
(*c*) Geoffrey E. Hill.
(*d*) Field investigation, design.
(*e*) Development of improved seeding criteria and evaluation procedures will lead to improved and reliable technology for increasing the water supply by snowpack augmentation.

152-11595-860-36

SAFE DRINKING WATER SURFACE IMPOUNDMENT ASSESSMENT

(*b*) U.S. Environmental Protection Agency.
(*c*) Donald B. Porcella.
(*d*) Experiment, basic research.
(*e*) The project will inventory water storage systems and aquifers to estimate the potential for contamination of the aquifers.

152-11596-630-88

TESTING A 24-INCH SWING CHECK VALVE AS PER WESTINGHOUSE INQUIRY

(*b*) Colorado State University.
(*c*) J. Paul Tullis.
(*d*) Experimental, operation.
(*e*) The valve will be tested to determine what range the valve causes loud snapping noises.

152-11597-340-73

A RESOURCE SURVEY OF HYDROELECTRIC POWER POTENTIAL IN UTAH

(*b*) Utah Power and Light Company.
(*c*) Calvin G. Clyde.
(*d*) Theoretical, basic research.
(*e*) This project will survey and summarize the hydroelectric power potential in Utah.

152-11598-310-38

AGENCY PROCEDURES FOR DETERMINATION OF PROJECT DESIGN FLOOD

(*b*) U.S. Water Resources Council.
(*c*) L. Douglas James.
(*d*) Theoretical, development.
(*e*) Officials from U.S. Army Corps of Engineers, Soil Conservation Service, Bureau of Reclamation, and the Tennessee Valley Authority were interviewed to determine how project design floods for reservoirs and levees are actually selected.

152-11599-630-05

LOW COST INSTANTANEOUS PUMP EFFICIENCY MONITOR

(*b*) U S. Department of Agriculture/ARS.
(*c*) Calvin G Clyde.
(*d*) Experiment, development.
(*e*) This effort will develop low cost instrumentation which will enable well owners, consultants, and others to monitor when maintenance is needed.

VIRGINIA INSTITUTE OF MARINE SCIENCE, COMMONWEALTH OF VIRGINIA, Department of Physical Oceanography and Hydraulics, Gloucester Point, Va. 23062. Dr. C. S. Fang, Department Head.

153-09165-400-60

COOPERATIVE STATE AGENCIES (CSA) ESTUARINE WATER QUALITY MODELING PROGRAM

(*b*) Virginia State Water Control Board, Richmond, Virginia.
(*c*) A Y Kuo, Senior Marine Scientist.
(*d*) Experimental, including field investigation and numerical modeling; applied research.
(*e*) A sequence of water quality models is being developed for Virginia estuaries for use by planning agencies as a management aid. The James, York, Rappahannock, and several smaller estuaries are included. The project commenced with one-dimensional salinity intrusion and dissolved oxygen models of the major estuaries but has expanded to encompass dynamic modeling, modeling of nitrogenous BOD and two-dimensional and two-layer modeling Also planned are ecosystem models including the nutrient cycle and the growth of phytoplankton.
(*g*) Field studies indicate that low oxygen conditions and high algal populations occur on a localized and seasonal basis, indicating the need for modeling to assess the impact of development on critical conditions. Estuarine stratification and water quality are clearly influenced by the annual hydrologic cycle.
(*h*) **A Water Quality Study of the Eastern Branch of the Elizabeth River,** G. C. Ho, A. Y. Kuo, B. J. Neilson, *VIMS SRAMSOE No. 126*, 1977.
Hydrography and Hydrodynamics of Virginia Estuaries, XI. Mathematical Model Studies of Water Quality of the Piankatank Estuary, H. S. Chen, P. V. Hyer, A. Y. Kuo, C. S. Fang, *VIMS SRAMSOE No. 124*, 1977.
A Water Quality Study of Buchanan Creek, A Small Tributary of the Lynnhaven Bay System, G. C. Ho, A. Y. Kuo, B J Neilson, *VIMS SRAMSOE No. 127*, 1977.
Hydrography and Hydrodynamics of Virginia Estuaries, XIV. Mathematical Model Studies of Water Quality of the Chickahominy Estuary, H. S. Chen, A. Y. Kuo, C. S. Fang, C. Cerco, *VIMS SRAMSOE No. 155*, 1979.
Mathematical Model Studies of the Ecosystem in the Upper Tidal James, A. Rosenbaum, A. Y. Kuo, C. S. Fang, C. Cerco, *VIMS SRAMSOE No. 155*, 1979.

153-09875-720-50

EOLE BUOY DATA PROCESSING AND INTERPRETATION

(*b*) National Aeronautics and Space Administration (Langley Research Center).
(*c*) E. P. Ruzecki, Assoc. Marine Scientist.
(*d*) Experimental, field investigation, applied research.
(*e*) Examine data from drifting buoys which were released near Chesapeake Light and other locations on the Virginia continental shelf and tracked by the French EOLE satellite. The relations between the buoy tracker, weather conditions, and hydrographic structure are being examined.
(*f*) Completed.
(*h*) **The Use of the EOLE Satellite Systems to Observe Continental Shelf Circulation,** E. P. Ruzecki, et. al, *Offshore Tech. Conf.*, May 1977.
Virginia Institute of Marine Science (VIMS)-NASA Langley Research Center (LaRC) EOLE BUOY Program, C. S. Welch, *AIAA Tech. Comm. Marine Systems and Technologies Symp. Free Drifting Buoys*, 1974.

153-09876-450-00

ON THE IMPORTANCE OF NORFOLK CANYON AND CONTINENTAL SHELF WATER CIRCULATIONS

(*c*) E. P. Ruzecki, Assoc. Marine Scientist.
(*e*) This study is intended to determine the importance of submarine canyons as an avenue of exchange for waters between the continental shelf and continental slope areas.
(*h*) *Ph.D. Dissertation*, Evon P. Ruzecki, University of Virginia.

153-09877-450-34

OUTER CONTINENTAL SHELF BENCHMARK STUDIES–PHYSICAL OCEANOGRAPHY

(*b*) U.S. Department of Interior (Bureau of Land Management).
(*c*) E. P. Ruzecki, Assoc. Marine Scientist.
(*d*) Field investigation, applied research.
(*e*) Measurements of temperature, salinity, dissolved oxygen, and micronutrients (nitrites, nitrates, and phosphates) at approximately 50 stations will be used to identify water masses in the study area. Data will be presented as cross-shelf sections of temperature, salinity, dissolved oxygen and density (sigma-t) and also as T-S plots for each station or group of stations.

153-09882-400-60

CHINCOTEAGUE BAY SYSTEM HYDROGRAPHICAL AND WATER QUALITY SURVEY STUDY

(*b*) Maryland Department of Natural Resources; Virginia State Water Control Board; Virginia Institute of Marine Science.
(*c*) C. S. Fang, Department Head, Senior Marine Scientist.
(*d*) Field investigation, design.
(*e*) A joint project involving the states of Virginia, Maryland, and Delaware has been undertaken to quantify the existing water quality of and the non-point pollution sources into the Chincoteague-Sinepuxent-Isle of Wight-Assawoman Bay complex. VIMS has reviewed and analyzed existing physical, biological, and chemical data, to design a detailed sampling program of the coastal basin. VIMS has developed two mathematical models: one to calculate the nonpoint wasteload, the other is to simulate the circulation of the Bay.
(*f*) Completed.
(*g*) The nonpoint source model can quantify the loading according to the land use plan. The hydrodynamic model

can predict the hydrographical changes in the Chincoteague Bay.

(*h*) **Index of Existing Data Sources for Chincoteague Sunepuxent, Assawoman and Little Assawoman Bays,** P. V. Hyer, J. Jacobson, C. S. Fang. Report to: Maryland Department of National Resources, Nov. 1975.
Intensive Hydrographical and Water Quality Survey of the Chincoteague/Sunepuxent/Assawoman Bay Systems, C. S. Fang, J. P. Jacobson, A. Rosenbaum, P. V. Hyer, *VIMS Special Scientific Report No. 82*, June 1977.
Intensive Hydrographical and Water Quality Survey of the Chincoteague/Sunepuxent/Assawoman Bay Systems. Vol. III. Nonpoint Source Pollution Studies in the Chincoteague Bay System, *VIMS SRAMSOE No. 86*.
A Mathematical model of Chincoteague Bay, Virginia, J. Vaccaro and J. Jacobson, *VIMS SRAMSOE No. 121*.

153-09887-870-68

DAM NECK CURRENT ANALYSIS

(*b*) Hampton Roads Sanitation District Commission through Malcolm Pirnie Engineers.
(*c*) C. S. Welch, Assoc. Marine Scientist.
(*d*) Experimental, applied research.
(*e*) An analysis of current meter data gathered by EG&G during summer and fall 1973 offshore from Virginia Beach, Va., is being performed. The object of the analysis is the determination of current parameters of interest in design and construction of a sewage treatment plant outfall diffuser. Those discussed include mean current, tidal ellipses for the M_2 tide, currents during winter storms, definition of the winter storm season and currents during hurricanes.
(*f*) Completed.
(*g*) Current records and meteorological records have been searched and interpreted to estimate some current related factors in the vicinity of Dam Neck, Virginia. The current data consists of approximately 30 day current meter records taken in summer 1973 and drogued buoy tracks recorded in autumn, 1972. Estimated quantities include vector averaged current, maximum anticipated current associated with winter storms, tidal current ellipses, the seasons during which winter storms can be expected, and the keys to the end and beginning of the winter (stormy) season in any given year.
(*h*) **Dam Neck Current Analysis Study,** C. S. Welch, K. P. Kiley, *VIMS SRAMSOE No. 151*, 1977.

153-09888-450-34

ANALYSIS OF THE GULF STREAM INTERACTION IN THE SOUTH ATLANTIC BIGHT

(*b*) Department of Interior (Bureau of Land Management), Environmental Research Technology, Inc. (ERT).
(*c*) Chris Welch, Assoc. Marine Scientist.
(*d*) Theoretical, applied research, data interpretation.
(*e*) The strength of interaction between the Gulf Stream and the continental shelf between Cape Hatteras and Cape Canaveral is being investigated. The technique of investigation involves remote sensing data and analysis of hydrographic data. A report containing the estimates will be submitted to BLM via ERT.
(*f*) Draft report completed and being reviewed.
(*g*) Satellite image data were found to be an incomplete source because of cloud cover and limited depth penetration. The Blake Plateau was found to be a singificant data gap. Spinoff eddies and longshore intrusions were suggested as separate shelf-Gulf Stream interactions important on an event scale. A several times per year oscillation was found in Raleigh Bay. This oscillation, found in previous studies is yet to be understood.
(*h*) **The Use of Remote Sensing in Studying the Physical Oceanography and Meteorology of the South Atlantic OCS Area,** J. c. Hayes, P. Kirshen, J. Bowley, C. Welch, B. Bernard, *Offshore Technology Conference*, 1978.
(Parts of) **Summary and Analysis of Physical Oceanographic and Meteorological Information on the Continental Shelf and Blake Plateau from Cape Hatteras to Cape Canveral.** Draft report to: Bureau of Land Management (through) Environmental Research and Technology, Inc. Unavailable pending acceptance.

153-11157-370-60

JAMES RIVER HYDRAULIC MODEL STUDY FOR THE PROPOSED THIRD CROSSING OF THE BRDIGE-TUNNEL AT HAMPTON ROADS

(*b*) Commonwealth of Virginia Highway Department, Virginia Institute of Marine Science.
(*c*) C. S. Fang, Department Head, Senior Marine Scientist.
(*d*) Experimental, development.
(*e*) An analysis of the expected changes to the physical and geological environment and stability of the Hampton Roads region, near the Newport News point, is being produced based on the existing data and the results of two hydraulic model studies. The model studies include hydrographic, confetti and gilsonite test runs of the James River Model at the Waterways Experimental Station of the Army Corps of Engineers in Vicksburg, Mississippi.
(*h*) **James River Hydraulic Model Study with Respect to the Proposed Third Bridge-Tunnel Causeway in Hampton Roads,** C. S. Fang, C. S. Welch, T. Brooks, R. J. Byrne, Report to: Commonwealth of Virginia Highway Department, Mar. 1979.

153-11158-400-68

HYDRODYNAMIC AND BIOGEOCHEMIMCAL WATER QUALITY MODELINGS

(*b*) Hampton Roads Water Quality Agency; Virginia State Water Control Board; Virginia Institute of Marine Science.
(*c*) H. S. Chen, Assoc. Marine Scientist.
(*d*) Applied research.
(*e*) A finite-element circulation and phytoplankton ecosystem model was developed, calibrated and verified for the lower tidal James River (from the mouth to the confluence with the Chickahominy). This model was used to analyze various proposals for point and nonpoint pollution abatement for the Hampton Roads 208 study.
(*g*) A depth-average two-dimensional hydrographical and biogeochemical water quality model has been developed. The biogeochemical water quality includes ten constituents: namely, salinity, coliform bacteria, phytoplankton, organic-N, ammonia-N, nitrite-nitrate-N, organic-P, inorganic-P, CBOD and DO deficit. The model is applied to simulate the water elevation, circulation and water quality in the lower James River, Hampton Roads.
(*h*) **Hydrodynamic and Biogeochemical Water Quality Models of Hampton Roads,** H. S. Chen, *VIMS SRAMSOE No. 147*, 1978.
Mathematical Simulation of Flow Circulation and Biogeochemical Water Quality, H. S. Chen, Abstract presented at Virginia Academy of Science, 56th Ann. Mtg., May 1978.
A Mathematical Model for Water Quality Analysis, H. S. Chen, *Proc. 26th Ann. Hydraulics Div. Specialty Conf. ASCE*, Aug. 1978.

153-11159-400-60

MATHEMATICAL MODELING OF WATER QUALITY IN A NETWORK WATERWAYS SYSTEM

(*b*) Virginia State Water Control Board; Virginia Institute of Marine Science.
(*c*) H. S. Chen, Assoc. Marine Scientist.
(*e*) A study to develop a hydrodynamic and water quality model in a network waterways system. The system not only includes the effects of physical and biochemical causes but also accepts the input of point and nonpoint waste sources. The model is then applied to a real estuarine waterways system.

153-11160-450-58

A MATHEMATICAL MODEL TO PREDICT FLOOD LEVELS IN CHESAPEAKE BAY DUE TO STORM SURGE

(*b*) The Federal Insurance Administration, Department of Housing and Urban Development.
(*c*) J. M. Zeigler, Asst. Director.
(*d*) Applied research.
(*e*) Develop a rational storm surge model for bay-ocean waters and apply to Chesapeake Bay. Flood-level frequency in the bay is determined through joint probability analysis to assess the insurance rate.
(*f*) Completed.
(*g*) A depth-averaged two-dimensional finite-element storm surge model consisting of a hydrodynamic model and a hurricane model has been developed. The model is applied to predict storm surge level in the Chesapeake Bay. Water circulation is a byproduct. Joint probability analysis is then employed to combine storm surge tides and astronomical tides to calculate flood-level frequency in the bay.
(*h*) **Volume I. Storm Surge Height-Frequency Analysis and Model Prediction for Chesapeake Bay,** J. D. Boon, C. S. Welch, H. S. Chen, R. J. Lukens, C. S. Fang, J. M. Zeigler, *VIMS SRAMSOE No. 189 (Draft)*, June 1978.
Volume II. A Finite Element Storm Surge Analysis and Its Application to a Bay-Ocean System, H. S. Chen, *VIMS SRAMSOE No. 189 (Draft)*, June 1978.

153-11161-870-60

MODELING KEPONE TRANSPORT IN THE JAMES ESTUARY OF VIRGINIA

(*b*) Commonwealth of Virginia.
(*c*) A. Y. Kuo, Sr. Marine Scientist.
(*d*) Field investigation, theoretical, applied research.
(*e*) Kepone is a highly persistent, toxic pesticide, which contaminates the entire James Estuary of Virginia as a result of carelessness in production and in waste disposal. To help assess the mitigation feasibility and evaluate mitigation alternative, a model of physical transport of kepone is being developed. Field studies found that the major portion of kepone in the water body is adsorbed to the sediment particles. Therefore the kepone transport is modeled as a two-phase process: the dissolved phase and adsorbed phase.

153-11162-400-00

THE EFFECT OF WIND ON CURRENTS IN A MODERATELY STRATIFIED ESTUARY

(*c*) C. S. Welch, Assoc. Marine Scientist.
(*d*) Data analysis, basic research, Master's thesis, K. Kiley (College of William and Mary).
(*e*) Current meter and meteorological records from the VIMS data bank are being used to assess the relation between wind and current in the York River, a moderately stratified estuary. The observed relations are being compared to various theories.

153-11163-870-60

ELIZABETH RIVER WATER QUALITY MODEL

(*b*) Virginia State Water Control Board.
(*c*) C. F. Cerco, Asst. Marine Scientist.
(*d*) Field study, applied research.
(*e*) Formulation of a real-time ecosystem model of the Elizabeth River System, located on the southside of Hampton Roads, Virginia has been completed. The model predicts time-varying longitudinal variations in salinity, organic nitrogen, ammonia nitrogen, nitrate nitrogen, organic phosphorous, ortho-phosphorous, chlorophyll, CBOD, dissolved oxygen and coliform bacteria. Both point and nonpoint source pollutants may be included as inputs.
(*f*) Completed.
(*g*) The Elizabeth River drains the urban areas of Norfolk, Portsmouth and Chesapeake, Virginia. The model shows the most significant deficit to the D. O. budget is benthal oxygen demand. The model also shows that density induced circulation due to variable salinity stratification greatly affects water quality in the river system.

153-11164-870-60

SALT MARSHES AS NON-POINT SOURCES OF BIOCHEMICAL OXYGEN DEMAND

(*b*) Virginia State Water Control Board.
(*c*) C. F. Cerco, Asst. Marine Scientist.
(*d*) Field study, applied research, Master's thesis, J. Sweeney (College of William and Mary).
(*e*) A study is being conducted into the existence and extent of the nitrification phenomena in the portion of the upper tidal James River extending from Richmond to Hopewell, Virginia. Water quality surveys are being employed in conjunction with a real-time nitrogen model of the river to determine the best form of bacterial kinetics which may be used to model nitrification in the river.
(*g*) Bacterial surveys show that nitrifying bacteria exist in both the water column and sediments of the James River.

153-11165-860-60

WATER QUALITY IN A SMALL TIDAL CREEK

(*b*) Virginia State Water Control Board.
(*c*) C. F. Cerco, Asst. Marine Scientist.
(*d*) Field investigation, applied research.
(*e*) A study is being conducted to determine the natural conditions in the creek. A water quality model is formulated to simulate the water quality in the creek and to determine the impact of the efficiency of the treatment facility with regard to the natural condition.

153-11166-860-60

ECOSYSTEM MODEL OF THE YORK ESTUARY

(*b*) Virginia State Water control Board; Environmental Protection Agency (through) Hampton Roads Water Quality Agency.
(*c*) P. V. Hyer, Assoc. Marine Scientist.
(*d*) Field investigation, applied research.
(*e*) A ten-component ecosystem model was constructed, calibrated and verified for the York River. The model components were: salinity, fecal coliform, three species of nitrogen, two species of phosphorous, chlorophyll, carbonaceous BOD and dissolved oxygen. The model had two layers to include the effect of the great depth of parts of the York. The calibration data were collected in two intensive surveys in June and July, 1976. The model was verified according to a low water slack run of September 13, 1976.
(*f*) Completed.
(*g*) The York was found to be oligotrophic and light-limited, owing to the high turbidity of the water. Secondarily, phytoplankton growth is nitrogen-limited. Dissolved oxygen exceeded five ppm, except in the deep layers (greater than 12 m) at the downstream end, which were depleted of oxygen. The bulk of the nitrogen occurred in the organic form, while phosphorous was about evenly split between organic and inorganic. In the process of tuning the model, a sensitivity matrix was drawn up, summarizing the response of each component to each input constant. On a percentage response basis, nitrate plus nitrite was found to be the most sensitive component, owing to its small concentration.
(*h*) **Water Quality Model of the York River, Virginia,** P. V. Hyer, *VIMS SRAMSOE No. 146*, Nov. 1977.
Ecosystem Model of the York River, Virginia, P. V. Hyer. Paper presented to Virginia Academy of Science, May 1978.
Verification of a York River Ecosystem Model, P. V. Hyer. Paper presented to *ASCE Specialty Conf. Verification of Mathematical and Physical Models in Hydraulic Engrg.*, Aug. 9-11, 1978.

153-11167-860-60

WATER QUALITY MODELING AND PROJECTIONS FOR THE BACK AND POQUOSON RIVERS, VIRGINIA

(*b*) Virginia State Water Control Board; Environmental Protection Agency (through) Hampton Roads Water Quality Agency.
(*c*) P. V. Hyer, Assoc. Marine Scientist.
(*d*) Field investigation, applied research.
(*e*) Branched one-dimensional phytoplankton ecosystem models were calibrated for the Back and Poquoson Rivers, then used to test proposed plans for abatement of non-point pollution for the Hampton Roads 208 study. Field data for calibration and verification were collected in the summer of 1975.
(*f*) Completed.
(*g*) Water quality in these rivers was generally good; however, coliform levels often exceeded standards and were notably high immediately following rainstorms.
(*h*) **Water Quality Models of Back and Poquoson Rivers, Virginia,** P. V. Hyer, A. Y. Kuo, B. J. Neilson, *VIMS SRAMSOE No. 144*, June 1977.

153-11168-400-60

ECOSYSTEM MODELS FOR THE RAPPAHANNOCK ESTUARY

(*b*) Virginia State Water Control Board.
(*c*) P. V. Hyer, Assoc. Marine Scientist.
(*d*) Field investigation, applied research.
(*e*) Ten-component ecosystem models are being constructed, calibrated and verified for the Rappahannock. One model will cover the reach from Fredericksburg to Port Royal; another will cover the entire estuary to the mouth. The model components are: fecal coliform, three species of nitrogen, two species of phosphorus, chlorophyll, carbonaceous BOD and dissolved oxygen. The second model includes salinity also. Calibration and verification data were collected in the summers of 1977 and 1978.
(*g*) The reach of the Rappahannock upstream of Port Royal is capable of achieving phytoplankton bloom conditions. This part of the river seems to be dominated by point sources, whereas farther downstream, point sources are few and far between.

153-11699-400-00

OBSERVATION OF THE SUDDEN DESTRATIFICATION IN THE YORK RIVER

(*c*) C. S. Welch, Assoc. Marine Scientist.
(*d*) Field investigation, basic research, Master's thesis, F. Holden (College of William and Mary).
(*e*) An experiment was planned and carried out to observe the sudden destratification in the York River predicted to occur in August, 1978 by L. Haas.

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY, College of Engineering, Department of Civil Engineering, Blacksburg, Va. 24061. Dr. R. D. Walker, Department Head.

154-09170-860-33

MATHEMATICAL MODELING OF STREAMFLOW AND WATER QUALITY IN THE UPPER REACHES OF THE CHOWAN RIVER

(*b*) Office of Water Research and Technology.
(*c*) D. N. Contractor, Assoc. Professor.
(*d*) Theoretical; applied research; Master's thesis.
(*e*) Two computer programs have been developed. The first is an implicit flow-routing model for the Chowan River system. This program can take into account lunar and wind tides. The second is a program which solves for the concentration of the following water quality parameters: BOD, COD, phosphorus, dissolved oxygen and four nitrogen parameters (organic, ammonia, nitrite-nitrate, algal). The four nitrogen parameters are solved for simultaneously. The results from the computer program have been compared with measured field data and reasonable agreement was obtained.
(*g*) The results of the computer simulation show that algal concentrations can become very high in the summer months when the temperatures are high and the flows are low. The relative contribution of each major source of nutrients to the algal concentration has also been obtained.
(*h*) **Nitrification Rates in the Chowan River Basin of Virginia,** C. T. Spangler, III, *M.S. Thesis*, Dept. Civil Engrg., VPI & SU, Dec. 1975.
Low Temperature Nitrification Kinetics in the Chowan River Basin of Virginia, V. A. Miller, *M.S. Thesis*, Dept. Civil Engrg., VPI & SU, July 1976.
Optimization of River Cross-Section for Use in Flood Routing Model, C. Tiyamani, *M.S. Thesis*, Dept. Civil Engrg., VPI & SU, Mar. 1977.
Mathematical Modeling of Streamflow and Water Quality in the Upper Reaches of the Chowan River, D. N. Contractor, P. H. King, *Bulletin 119*, Virginia Water Resources Research Center, Blacksburg, Va., 1979.
Simulation of Algal Growth in the Chowan River, D. N. Contractor, *Proc. 26th Ann. ASCE Hydraulics Div. Specialty Conf., Verification of Mathematical and Physical Models in Hydraulic Engrg.*, Univ. Maryland, College Park, Md., pp. 253-264, Aug. 1978.

154-09906-200-00

DETERMINATION OF MANNING'S COEFFICIENT FOR OVERLAND FLOW USING A FINITE ELEMENT MODEL

(*c*) D. N. Contractor, Assoc. Professor.
(*d*) Theoretical; applied research; Ph.D. thesis.
(*e*) Manning's coefficient "n" for open channel flows with vegetative growth are available in the technical literature. However, when routing rainfall excess over a watershed area, the appropriate "n" values to be used as a function of land use are not available. This study is directed at obtaining these values using an optimization technique together with a finite element model of overland flow. The South River watershed near Waynesboro, Va., is used as a test area. For a given rainfall, the program first calculates the rainfall excess and then routes the excess over the land and then in the stream. Comparisons are made between the computed and measured streamflows at Waynesboro. The error between these two curves is systematically reduced by the optimization technique. The optimized "n" values will be tested for validity using other storms.

154-11169-810-05

SPATIAL REPRESENTATION AND HYDROLOGIC MODELING

(*b*) Hydrograph Laboratory, Science and Education Administration, U.S. Dept. of Agriculture, Beltsville Agri. Research Center, Beltsville, Md. 20705.
(*c*) D. N. Contractor, Assoc. Professor.
(*d*) Theoretical; applied research; Ph.D. thesis.
(*e*) A finite element model of overland flow and stream flow has been developed to simulate the runoff from a watershed due to a given rainfall. This model has been tested in many watersheds and for many storms and has given satisfactory results. This model will be used to study the quantity of soil sampling data that is necessary to properly model the runoff. It is apparent that the cost of data collection and computer simulation increases rapidly as the quantity of data increases. thus, it is desirable to be able to use a minimum quantity of data necessary for a given level of accuracy of output of the model. This study is an attempt at defining that minimum quantity of soil sampling data.

154-11170-830-33

APPLICATION OF FINITE ELEMENT MODEL TO PREDICT SEDIMENT LOADS FROM AGRICULTURAL WATERSHEDS

(*b*) Virginia Water Resources Research Center, Office of Water Research and Technology.
(*c*) D. N. Contractor, Assoc. Professor.
(*d*) Theoretical; applied research.
(*e*) This study will combine an existing finite element storm hydrograph model with relationships for sediment detachment and transport and route the resulting sediment concentrations through the stream. The model uses a distributed parameter analysis that accounts for spatial and temporal variations of those factors relevant to the processes of soil loss and sediment transport. This approach provides the modeling framework to meet a critical need in the implementation of erosion control measures.
(*g*) Preliminary runs of the sediment model show that the sediment concentration graph is roughly similar to the flow hydrograph. This behavior has been observed before and is to be expected. The model will be verified against measured sediment concentrations from different watersheds.
(*h*) **A Finite Element Hydrologic Model to Determine the Effect of Land Management Practices on Erosion and Sedimentation in a Watershed,** B. B. Ross, V. O. Shanholtz, D. N. Contractor, *Paper No: 78-2507, Winter Mtg., Amer. Soc. Agric. Engr.*, Chicago, Ill., Dec. 8-20, 1978.

UNIVERSITY OF VIRGINIA, Chemical Engineering Department, Charlottesville, Va. 22901. Dr. J. L. Hudson, Chairman.

155-10015-120-00

VISCOELASTIC FLUID BEHAVIOR

(*c*) Dr. L. U. Lilleleht, Assoc. Professor.
(*d*) Experimental and theoretical for Doctoral theses.
(*e*) Investigation of the kinematics and the stress fields near the stagnation point with polyisobutylene solutions flowing in T-shaped and in expanding/contracting channels.
(*f*) Temporarily suspended.
(*g*) Velocity field was determined by Laser-Doppler-Anemometry and the normal stress differences by flow birefringence. These data were used to evaluate a number of constitutive equations. A "stagnant" zone of finite thickness was detected near the stagnation point.
(*h*) **Kinematics of Plane Stagnation Flow,** A. Berker, L. U. Lilleleht, *Industrial and Engineering Chemistry Fundamentals*, *15:4*, 425-430, 1977.

VOUGHT CORPORATION ADVANCED TECHNOLOGY CENTER, P.O. Box 226144, Dallas, Tex. 75266. Dr. F. W. Fenter, Vice-President, Vought Corporation Research and Advanced Technology.

156-09925-250-20

COMPLIANT WALL DRAG REDUCTION

(*b*) Office of Naval Research.
(*c*) Dr. C. H. Haight, Manager, Aerodynamic and Propulsion Research.
(*d*) Experimental, basic research.
(*e*) Evaluate systematically the effects of compliant membrane/substrate properties on turbulent skin friction. This is directed towards the achievement of a practical means for reducing drag on hydrodynamic vehicles.
(*f*) Completed.
(*g*) Rotating disk and water channel tests of candidate compliant surfaces have been completed. Results have provided parameter data to eliminate significant ranges of materials from consideration.
(*h*) **Hydrodynamic Drag Measurements on Compliant Surface Disks,** T. D. Reed, G. R. Hough, *Report No. B-91100/8CR-77*, June 1978.

156-11171-250-20

ACTIVELY-DRIVEN COMPLIANT WALL

(*b*) Office of Naval Research.
(*c*) Dr. C. H. Haight, Manager, Aerodynamic and Propulsion Research.
(*d*) Experimental; basic research.
(*e*) Investigate the hydrodynamic drag reduction potential of actively-driven compliant surfaces in turbulent flow. Identify promising driving systems and carry out water channel tests for concept verification.
(*g*) Various active driver concepts have been assessed. Initial studies of a magnetically driven membrane/ferrofluid have been undertaken to identify key parameters and determine feasibility.

WASHINGTON STATE UNIVERSITY, The R. L. Albrook Hydraulics Laboratory, Department of Civil and Environmental Engineering, Pullman, Wash. 99164. Professor John A. Roberson, Laboratory Head.

157-09196-340-73

HYDRAULIC MODEL STUDIES OF ROCK TRAPS–HELMS PUMPED STORAGE PROJECT

(*b*) Pacific Gas and Electric Company.
(*c*) Claud C. Lomax, Hydraulic Engineer.
(*d*) Experimental; applied research.
(*e*) Study determined the coefficients of two surge tank orifices and the effectiveness of the tunnel rock traps.
(*f*) Completed.
(*h*) **Hydraulic Model Studies of Surge Tank Orifices and Tunnel Rock Trap,** C. L. Lomax, A. F. Babb, *Tech. Rept. HY-5/77*.
Minimum Reynolds Number for Physical Model Similarity, A. F. Babb, J. Amorocho, C. C. Lomax, *ASCE Hydraulics Div. Conf.*, Aug. 9-11, 1978.

157-10132-300-34

HYDRAULIC CHARACTERISTICS OF THE YAKIMA RIVER FOR ANADROMOUS FISHERIES

(*b*) U.S. Fish & Wildlife Service, Columbia River Fisheries Program.
(*c*) Howard D. Copp, Professor and Hydraulic Engineer.
(*d*) Field investigation, applied research, development.
(*e*) Determine stream flowrates that are conducive to spawning and rearing by Pacific salmon species in the Yakima River, Washington. Systematic measurement of velocities and depths at various flowrates have been made over a period of 18 months. Comparing these with known spawning and rearing habitat of the species, preferred spawning and rearing discharges have been identified at eight locations along the 200 mile river and/or sites on tributaries to the Yakima River.
(*g*) Existing flow regimes are conducive to spawning and rearing at most locations studied. In some instances, regulated low flows may have to be increased. Riverbed erosion and deposition would hinder egg survival in certain locations. Future man-induced effects should be implememted with the spawning characteristics firmly in mind.
(*h*) **Hydraulic Characteristics of the Yakima River for Anadromous Fish Spawning,** H. D. Copp, J. N. Rundquist, *Tech. Rept. HY-2/77*, 112 pages, 1977.

157-10134-300-88

LOW FLOW AUGMENTATION OF THE UMATILLA RIVER FOR ANADROMOUS FISH SPECIES

(*b*) Confederated Tribes of the Umatilla Indian Reservation.
(*c*) Howard D. Copp, Professor & Hydraulic Engineer.
(*d*) Experimental, theoretical, applied research.

(*e*) Hydrologic water balances were developed for several watersheds comprising the Umatilla basin above Pendleton, Oregon. Historical runoff patterns were developed and were compared with those required for spawning and rearing by anadromous fish. Ungaged streamflows were predicted on the basis of geomorphic parameters developed by other researchers. These compared quite favorably with intermittent measurements made on those streams. Water availability for augmenting low summer flows and an examination of streamflow regulation possibilities were completed.

(*h*) **Geomorphology, Hydrology, and Streamflow Management in Upper Umatilla River Basin, Oregon,** H. D. Copp, *Tech. Rept. HY-4/77*, 49 pp., Sept. 30, 1977.

157-11172-870-75

WASTE HEAT EFFLUENT DISPERSAL FROM A SUBMERGED MULTI-PORT DIFFUSER

(*b*) Ebasco Services, Inc., New York; Washington Public Power Supply System, Richland, Washington.

(*c*) Howard D. Copp, Professor and Hydraulic Engineer.

(*d*) Experimental; applied research; operations.

(*e*) Dispersion of heated effluent from a multi-port diffuser submerged in the Chehalis River, Washington, was examined on a 1:12 scale hydraulic model under a variety of low flow regime stream conditions and diffuser flowrates and temperatures. Dispersion mechanics were studied in the model through measurement of stream temperatures via a bank of 230 thermistor units. Experimental measurements were made with a steady downstream river flow regime as well as under a number of different tidal conditions. The intent was to determine whether the planned diffuser operation would meet the state of Washington water quality standards. Relationships between momentum flux ratios and densimetric Froude number and the areal extent of various dilution factors were developed. These were then interpreted in view of water quality standards in a possible mixing zone. Parts of this study will be presented to the State of Washington Energy Facility Site Evaluation Council in a hearing by that group to study a modification request for operating permits for two thermal nuclear electric energy development plants.

(*h*) **Thermal Hydraulic Model Studies of the Diffuser Performance, Washington Public Power Supply System, Nuclear Power Project Nos. 3 and 5, Chehalis River, Washington,** H D. Copp, *Tech. Rept. HY-2/78*, 97 pp., Dec. 1978. (This is a popularized version of a technical report yet to be prepared. This report was prepared specifically for the Site Evaluation Council.)

157-11173-210-00

FLOW IN ROUGH CONDUITS

(*c*) John A. Roberson, Professor and Hydraulic Engineer.

(*d*) Experimental and theoretical; basic research for Ph.D. thesis.

(*e*) Previous basic research has developed the method for predicting the resistance to flow in artificially roughened conduits and in rock bedded streams. This research is primarily focused on developing the method to analytically predict the resistance in commercially rough conduits.

(*g*) The method developed allows flow resistances to be predicted from traces of roughness profiles of the conduit. The method is applicable to partially rough or fully rough pipe and it has revealed new concepts about flow in rough conduits.

157-11174-030-54

EFFECTS OF TURBULENCE ON THE PRESSURE DISTRIBUTION AND VIBRATION OF ANGULAR BODIES

(*b*) National Science Foundation.

(*c*) John A. Roberson, Professor and Hydraulic Engineer.

(*d*) Experimental and theoretical; basic research for M.S. thesis.

(*e*) Investigate the effect of free-stream turbulence on the pressure distribution, drag and vibration of angular bodies.

(*f*) Completed.

(*g*) Results show that the pressure distribution is markedly influenced by free-stream turbulence and that the extremes of pressure are attenuated by decreasing height to width ratio of the body. It was also found that the level of turbulence intensity and damping ratio have distinct and unpredictable effects on the aeroelastic vibration of square and H-sections if the onset velocity is less than the resonant velocity.

(*h*) **Pressure Distribution on Model Buildings at Small Angles of Attack in Turbulent Flow,** J. A. Roberson, C. T. Crowe, *Proc. 3rd U.S. Natl. Conf. Wind Engrg. Research*, Feb. 1978, Univ. of Florida, Gainesville.

The Aeroelastic Vibration of the Square and H-Shaped Sections in Turbulent Cross Flows, J. lee, *M.S. Thesis*, Dept. of Mech. Engrg., Washington State Univ., Pullman, Wash., 1978.

157-11175-010-54

A NUMERICAL MODEL FOR BOUNDARY LAYER FLOW OVER A VERY ROUGH SURFACE

(*b*) Partially supported by National Science Foundation.

(*c*) John A. Roberson, Professor and Hydraulic Engineer.

(*d*) Experimental and numerical modeling; basic research for M.S. thesis.

(*e*) Considering the local drag of roughness elements with elevation as well as the resistance of the boundary on which the elements are placed, a numerical model was developed to predict the velocity distribution over a boundary on which tall roughness elements are placed. The velocity distribution is given above the tops of the elements as well. Also this model predicts the shear stress produced by the boundary.

(*g*) The numerical results compare very well with experimental results.

(*h*) **The Velocity Distribution Below the Tops of Uniform Roughness Elements,** D. K. Carlton, *M.S. Thesis*, Dept. of Civil and Environmental Engrg., Washington State Univ., Pullman, Wash. 99164, 1979.

157-11176-340-52

A RESOURCE SURVEY OF LOW-HEAD HYDROELECTRIC POTENTIAL IN THE PACIFIC NORTHWEST REGION

(*b*) U.S. Dept. of Energy, Sponsor; Idaho Water Resources Research Institute, Prime Contractor; Washington Water Research Center, Subcontractor.

(*c*) Claud C. Lomax, Hydraulic Engineer.

(*d*) Theoretical; applied research.

(*e*) Project will determine the potential energy available in natural streams, at dams not currently used for power generation, and at irrigation structures. The data will be analyzed and summarized to show the potential MW and GWH developments at various exceedance flow. This will be done for all Washington streams wherever the average annual flow exceeds 35 cfs and the power available exceeds 200 kW.

(*h*) A combined report for the states of Idaho, Montana, Oregon, and Washington is being prepared by the Idaho Water Resources Research Institute. Report on the Washington data are planned as independent projects.

157-11177-030-54

EFFECT OF TURBULENCE ON THE PRESSURE DISTRIBUTION IN THE VICINITY OF ROUNDED CORNERS OF PRISMATIC BODIES

(*b*) Partially funded by National Science Foundation.

(*c*) John A. Roberson, Professor and Hydraulic Engineer.

(*d*) Experimental; basic research.

(*e*) The pressure in the vicinity of rounded corners of prismatic bodies was measured for different intensities of free-stream turbulence and different degrees of rounding.

(*f*) Suspended.

(*g*) Experimental results show that high levels of turbulence intensity produces a much lower pressure coefficient in the vicinity of the rounded corner than for low levels of turbulence.

(*h*) **Pressure Distribution on Model Buildings at Small Angles of Attack in Turbulent Flow,** J. A. Roberson, C. T. Crowe, *Proc. 3rd U.S. Natl. Conf. Wind Engrg. Research*, Feb. 1978, Univ. of Florida, Gainesville.

157-11178-400-33

CIRCULATION IN BAKER BAY

(*b*) Office of Water Research and Technology.
(*c*) John A. Roberson, Professor and Hydraulic Engineer; Howard D. Copp, Professor and Hydraulic Engineer.
(*d*) Theoretical; applied research.
(*e*) A two-dimensional model is being developed to predict the velocity distribution in Baker Bay (Baker Bay is near the mouth of the Columbia River). The object of the model is to assist in the development of measures to alleviate sedimentation problems of the navigation channels in Baker Bay.
(*g*) The initial model has been developed.

157-11179-850-60

DEVELOPMENT OF A MACHINE FOR THE RESTORATION OF SALMON STREAMS

(*b*) Washington State Department of Fisheries; National Marine Fisheries Service; State of Washington Water Research Center.
(*c*) Walter C. Mih, Assoc. Professor.
(*d*) Experimental; M.S. thesis project.
(*e*) Increased fine sediment from logging, construction and farming activities continues to cause a loss of salmonid spawning habitat by reducing intragravel water flow necessary for egg incubation. A detailed review of gravel cleaning methods reveals that the best alternative is the use of high velocity water jets coupled with suction system to dislodge and remove the silt. Optimum jet diameter, jet velocity, and suction hood configuration have been determined from laboratory testing results.
(*g*) A prototype machine is being designed and built.
(*h*) **A Review of Restoration of Stream Gravel for Spawning and Rearing of Salmon Species,** W. C. Mih, *Amer. Fisheries Soc.* **3,** No. 1, pp. 16-18, Jan. 1978.
Hydraulic Restoration of Stream Gravel for Spawning and Rearing of Salmon Species, W. C. Mih, *Tech. Rept. HY-3/78*, State of Washington Water Research Center, Pullman, Wash. 99164.

157-11180-320-00

DESIGN OF RIGHT-ANGLE BENDS IN BAFFLED CHUTES

(*c*) David T. Higgins, Associate Professor.
(*d*) Experimental; applied research.
(*e*) Centrifugal flow effects lead to a nonuniform flow distribution in the reach of the baffled chute downstream of the bend. This causes more scour than that found below straight chutes. A series of tests in a 1:12 model seeks ways to minimize the additional scour.

157-11181-300-00

ANALYSIS OF BASIN CHARACTERISTICS, STREAM FLOW AND CHANNEL GEOMETRY OF THE ST. MARIES RIVER BASIN IN NORTHERN IDAHO

(*c*) John F. Orsborn, Chairman and Professor, Dept. of Civil and Environmental Engineering.
(*d*) Experimental field work to confirm theoretical and parameteric analysis; basic research; M.S. thesis project.
(*e*) A geomorphic, hydrologic and hydraulic analysis of the interrelationships between basin geomorphic characteristics (area, stream length, and basin relief), average precipitation, average annual flows, flood flows, low flows, channel width, depth and velocity, and substrate size is being conducted to develop a new parameteric-process model for ungaged flow prediction and potential impact analysis.
(*g*) Preliminary correlations of basin, flow, and channel characteristics have been developed.

157-11182-350-75

MAQARIN SPILLWAY PROJECT

(*b*) Harza Engineering Company.
(*c*) Alan F. Babb, Professor and Hydraulic Engineer.
(*d*) Experimental; applied research; development.
(*e*) Hydraulic model investigation of a twin-tunnel spillway conveying water from a gated crest structure to a downstream flip bucket. Special attention will be given to the development of aeration devices to prevent the occurrence of cavitation.
(*f*) Initial phase.

157-11183-870-00

HYDRAULICS OF INLETS TO SETTLING BASINS

(*c*) Alan F. Babb, Professor and Hydraulic Engineer.
(*d*) Experimental; applied research; M.S. thesis project.
(*e*) Study to determine the effect of various geometries on the uniformity of flow entering a settling basin.

157-11184-450-00

THE EFFECT OF RESERVOIR FLUCTUATIONS ON CIRCULATION IN RECREATIONAL EMBAYMENTS

(*c*) Alan F. Babb, Professor and Hydraulic Engineer.
(*d*) Experimental; applied research; M.S. thesis project.
(*e*) Use of a physical model of a generalized embayment configuration to measure flow exchange betwen the embayment and the reservoir, and to examine the effects of embayment size, opening size and location, and presence of second opening of flow exchange and circulation patterns.

157-11185-200-00

THE PREDICTION OF ENERGY LOSSES IN SUB-CRITICAL OPEN-CHANNEL EXPANSIONS

(*c*) Alan F. Babb, Professor and Hydraulic Engineer.
(*d*) Experimental; applied research; M.S. thesis project.
(*e*) A study to adapt diffuser theory to the prediction of losses in open channel expansions.

UNIVERSITY OF WASHINGTON, College of Fisheries, Fisheries Institute, Seattle, Wash. 98195. Robert L. Burgner, Institute Director.

158-06834-850-45

CHUM SALMON SPAWNING CHANNEL

(*b*) National Marine Fisheries Service (Anadromous Fish Act Funds).
(*c*) Dr. E. O. Salo.
(*d*) Experimental field investigation; applied and basic research; two Ph.D. and two Masters theses projects are being supported.
(*e*) An experimental stream and hatchery have been built at the University of Washington's field station on Big Beef Creek, Hood Canal. These facilities are being used to examine the affects of sexual selection on overall mating patterns in chum salmon; evaluate parental affects on progeny viability and growth; determine the possibility of maximizing fry production in spawning channels by controlled superimposition of adults; assess the practicality of improving spawning beds by the addition of various amounts of gravel; delineate the behavioral responses of female salmon to different gravel compositions; and examine the ethological isolating mechanisms used by Pacific salmon to prevent genetic introgression.
(*g*) Overall mating patterns in chum salmon populations varied depending on the amount of male intrasexual competition. Moreover, females showed preferences for large and socially dominant partners. It was found that egg size affected fry size at emergence but paternal age and size at maturity did not influence progeny growth or viability during a rearing experiment that lasted 14 weeks. Data in-

dicated that successive groups of chum salmon could utilize the same spawning areas if previously deposited eggs were allowed to become immune to mechanical shock. Egg-to-fry survival was improved in areas containing high amounts of sand if a layer of gravel, 30 cm thick, was placed over them before spawning occurred. Moreover, female chum salmon exhibited preferences for spawning gravels with low concentrations of sand. The investigations dealing with ethological isolating mechanisms in salmon have indicated that both visual and olfactory information may play roles in species identification.

(*h*) Annual reports of work are available for the years 1972 through 1977. One Ph.D. Dissertation and three Master Theses have been completed. Moreover, one additional Ph.D. Dissertation and two more Masters Theses will be available by January 1980.

158-11208-850-73

SKAGIT RIVER FISHERY INVESTIGATIONS

(*b*) Seattle City Light.

(*c*) Dr. Robert L. Burgner, Director, FRI.

(*d*) Field investigation; applied research; one Ph.D. thesis project and three Master's theses projects were supported.

(*e*) Establish ecological baseline data for the aquatic environment of the Skagit River between Newhalem and Concrete and contribute information relevant to three Seattle City Light projects: High Ross Dam, Copper Creek Dam, and relicensing of the Skagit Project. The results provide a basis to assess the present and predicted reservoir-related effects of the Skagit Project on the downstream fishery resources of the Skagit River.

(*f*) Completed.

(*g*) Exposure to desiccation during flow fluctuations reduced the periphyton standing crop and the density of benthic insects in the Skagit along the stream margins. The degree of reduction during periods of hydroelectric peaking was related to the amount of time the substrates were exposed during dewatering, with the least amount of reduction on deeper, less frequently exposed substrates.

Community composition of aquatic insects in shoreline areas of the Skagit was also affected by flow fluctuation. Species susceptible to stranding or intolerant to exposure to desiccation were eliminated or reduced in the marginal areas of the river. The resulting community composition was dissimilar to composition in deeper, unexposed areas of the Skagit and to composition in the unregulated Sauk and Cascade rivers.

Crustacean zooplankton survived passage through the hydropower dams on the Skagit, as evidenced by the large number of unbroken, viable specimens collected in the tailrace stations and in the Skagit River below Gorge Dam. Feeding on zooplankton by salmonid fry appeared sporadic and opportunistic. Zooplankton was available to salmonid fry as far downriver as the Concrete Station, about 37 river miles downstream of Gorge Powerhouse.

Incubation studies were conducted using eggs from Skagit River chinook, pink, chum, and coho salmon to determine the temperature unit (TU) requirements to hatching and yolk absorption for these species and to assess the effects of the present temperature pattern on salmonid egg incubation and timing of fry emergence. Eggs were incubated in the mainstem Skagit River and at sites warmer and cooler than the Skagit.

The developmental rate and TU requirements to hatching and yolk absorption for Skagit chinook salmon were shown to be influenced by mean incubation temperature and egg size. The relationship with egg size was that the larger and heavier eggs required more TU's to yolk absorption than did the smaller and lighter eggs. Egg size and fry size were shown to be related: the larger the egg, the larger the resulting fry. For eggs of similar size from a single female chinook, the TU requirements were shown to be highly correlated to mean temperature during the incubation period. Confounding effects are possible when both factors vary simultaneously. The observed effects of mean incubation temperature suggest that the developmental rate was altered by a compensating mechanism so that at higher temperature more TU's were required and at lower temperature fewer TU's were required. Such a mechanism would presumably improve fish survival by tending to maintain their emergence at a specific time of year when environmental conditions are more favorable.

The mean number of TU's required to mean hatching was 981, 953, 816, and 777, for Skagit chinook, pink, chum, and coho salmon, respectively, incubated in the Skagit River, whereas 1930, 1692, 1561, and 1298, respectively, were required to mean yolk absorption.

Salmonid fry were collected regularly in the Skagit River and in the unregulated Sauk and Cascade rivers through April 1978. Size, condition, and diet were determined for captured fry.

For chinook, rainbow-steelhead, and coho fry in our study area, there generally was an initial period after first emergence with little increase or even decline in mean length, weight, and condition factor. Within each species, the size and condition at all sites were similar during this period. This initial level period is thought to be partly due to continual emergence of fry from the gravel through this period.

After the initial level period, there was a tendency for chinook, coho, and rainbow-steelhead fry from the unregulated Sauk River to be larger and to have higher condition factors than fry from the unregulated Cascade River and the regulated Skagit River during the same week in 1975 and 1976, except for rainbow-steelhead and coho fry in fall and winter. Fry from the Skagit River tended to be smallest and have the lowest condition factor.

Aquatic insects were the most important component by number in chinook, pink, chum, coho, and rainbow-steelhead fry diets in the Skagit, Sauk, and Cascade rivers. In general, chironomids and Ephemeroptera nymphs were the two most important groups of aquatic insects.

Water level fluctuations caused by fluctuations in power generation at Gorge Dam can result in the stranding of salmon fry in the upper Skagit River. Of the many factors involved in stranding, the rate of flow reduction (ramping rate) and the level of minimum flow were suspected as being most important. Analyses of these factors indicated a correlation between stranding mortality and both ramping rate and the level of minimum flow.

Quarterly sampling was conducted in the mainstem Skagit for fishes other than salmon and adult steelhead trout. Mountain whitefish was the most abundant species captured, composing about 89 percent of the catch, followed by largescale sucker at 6 percent, Dolly Varden char at 3 percent, and rainbow-steelhead trout at 2 percent.

Other species captured incidentally during our sampling were: Brook trout, threespine stickleback, sculpin, brook lamprey, and longnose dace. There was a noted absence of cutthroat trout in Skagit tributaries within the study area.

(*h*) **Assessment of the Reservoir-Related Effects of the Skagit Project on Downstream Fishery Resources of the Skagit River, Washington,** J. P. Graybill, R. L. Burgner, J. C. Gislason, P. E. Huffman, K. H. Wyman, R. G. Gibbons, K. W. Kurko, Q. J. Stober, T. W. Fagnan, A. P. Steyman, D. M. Eggers, Fish. Res. Inst., Univ. Washington, *Final Rept. FRI-UW-7905*, 602 pp., 1979.

The Effect of Dam-Related Temperature Changes on the Early Life History of Chinook Salmon in the Skagit River, R. G. Gibbons, *M.S. Thesis*, Univ. Washington, 63 pp., 1977.

Investigations on the Amount of Potential Spawning Area Available to Chinook, Pink, and Chum Salmon in the Upper Skagit River, Washington, K. W. Kurko, *M.S. Thesis*, Univ. Washington, 76 pp., 1977.

The Effects of Flow Fluctuation on Benthic Insects in the Skagit River, J. C. Gislason, *Ph.D. Thesis*, Univ. Washington (in preparation).

The Effects of Environmental Factors on the Availability, Diet, Size, and Condition of Skagit River Juvenile Salmonids, P. E. Huffman, *M.S. Thesis*, Univ. Washington (in preparation).

Information about the above publications can be obtained from: Ms. Dorothy Beall, Fisheries Publications Office, Fisheries Research Institute WH-10, University of Washington, Seattle, Wash. 98195.

158-11209-850-60

EFFECTS OF LOGGING STUDY, CLEARWATER RIVER SYSTEM

(*b*) Washington state Department Natural Resources.
(*c*) Dr. E. O. Salo and C. J. Cederholm.
(*d*) Field and laboratory investigation; applied research; one Ph.D. and eight Masters theses projects are either completed or underway.
(*e*) We have determined that sedimentation caused by construction, use and maintenance of logging roads is a significant cause for increases in the levels of "fine particles (less than 0.85 mm diameter) in substrates of streams used by salmon for spawning and rearing. Studies are on the effects of sediments on coho salmon, and steelhead and cutthroat trout habitats. The change in salmonid population size, recruitment, and production is correlated to changes in habitat and with ocean and rivers fishery harvest.
(*g*) Fluctuations in abundance of juvenile salmon and trout may be caused by a combination of over-harvest and poor logging practices. Approximately one thousand gravel samples from areas used by salmon and trout for spawning have been analyzed in the past six years. Statistically significant positive correlations exist between miles of logging road versus the amount of spawning gravel siltation.

Laboratory stream studies indicate that juvenile coho salmon may not avoid water with suspended sediment levels several times greater than what occurs in nature. Static bioassay experiments indicate a wide seasonal range of tolerance levels.

Removal of debris from streams had little effect on numbers and biomass of trout immediately after alteration and prior to winter. Subsequently large reductions did occur over the first winter but these losses were short term.

Studies are continuing on the impacts of logging and associated practices on the fisheries habitat and resources of the Clearwater River.

158-11210-850-31

BANKS LAKE FISHERY INVESTIGATIONS

(*b*) U.S. Bureau of Reclamation; Pacific Northwest Regional Office and Columbia Basin Irrigation Project.
(*c*) Dr. Q. J. Stober.
(*d*) Basic and applied research, design, operation and development.
(*e*) A net barrier 1,341 m in length was developed to screen adult kokanee from the main irrigation canal intake in Banks Lake, the equalizing reservoir for the Columbia Basin Project. The net barrier was operated during two years. A comprehensive evaluation of the population included canal entrainment sampling estimation of the spawning population in the reservoir, sport catch, and behavior of screened individuals. The impact of reservoir drawdown on kokanee egg and fry survival was evaluated by trapping emergent fry at depth intervals in the spawning areas. Rule curves were developed to allow fry emergence.
(*g*) Annual canal entrainment of kokanee declined from 60-67 percent before to 18-3 percent after installation. An estimated 35,381 adults were retained in the reservoir during 1978. A creel census estimated anglers caught 46,427 kokanee in 1978. The catch per angler hour was 0.250 while all other species declined to 0.042. The net barrier was successful in retaining kokanee for the sport catch and spawning in the lake. Spawners concentrate along talus shoreline areas at depths between 1.5 and 4.6 m below full pool. Drawdown was found to reduce year class strength due to the dessication of eggs and fry. Drawdown should be limited to 5.18 cm/day during the fry emergence period to allow survival.
(*h*) **Development and Evaluation of a Net Barrier to Reduce Entrainment Loss of Kokanee from Banks Lake,** Q. J. Stober, R. W. Ryler, C. E. Petrosky, R. Johnson, C. F. Cowman, J. Wilcock, R. E. Nakatani, *Final Report April 21, 1977 to March 31, 1979 to U.S. Bureau of Reclamation*, 243 pp.

Operational Effects of Irrigation and Pumped Storage on the Ecology of Banks Lake, Washington, Q. J. Stober, R. W. Tyler, J. A. Knutzen, D. Gaudet, C. E. Petrosky, R. E. Nakatani, *Final Report June 1973 to Sept. 1977 to U.S. Bureau of Reclamation*, 297 pp.

158-11211-850-33

CEDAR RIVER FISHERY INVESTIGATIONS

(*b*) State of Washington Water Research Center; Office of Water Research and Technology, U.S. Department of Interior, City of Seattle Water Department and Washington State Department of Fisheries.
(*c*) Dr. Q. J. Stober.
(*d*) Basic and applied.
(*e*) The factors controlling reproduction and early development of sockeye salmon are being investigated including augmented low flows, uncontrolled floods and density-dependent mortality. Estimation of fry survival and production in the river under several environmental regimes will determine the water and fisheries management requirements resulting in optimum production.
(*g*) Low flows during the spawning season were augmented as the season progressed to maximize the use of the area available to spawners. Higher egg deposition efficiencies occurred on reaches where spawning area accumulated with an increase in discharge. Substrate scouring due to a flood (249.3 m^3/s) reduced egg/alevin densities by 50.6 and 96.6 percent on two reach types sampled. The presmolt-to-spawner ratio ranged from 5.8 following the flood to 20.2 following augmented low flow and no flood. Fry production during two years was 1.76×10^6 and 22.8×10^6 representing survival rates of 0.81 and 8.1 percent during flood and nonflood years. A sustained loss of spawning habitat due to the loss of spawning gravel was found to persist following major flooding. These results should help to establish an efficient escapement goal for the Cedar River sockeye and find application on salmon streams affected by hydroelectric spawning area to benefit fish production.
(*h*) **Effects of Discharge in the Cedar River on Sockeye Salmon Spawning Area,** Q. J. Stober, J. P. Graybill, *Final Report to City of Seattle Water Department, FRI-UW-7407*, 39 pp., 1974.

Instream Flow and the Reproductive Efficiency of Sockeye Salmon, Q. J. Stober, R. E. Narita, A. H. Hamalainen, Completion Report for Matching Grant Project, OWRT Proj. B-065-WASH, OWRT Agreement 14-31-0001-6132, Washington Water Research Center, Seattle Water Dept. and METRO, Univ. Washington, Fisheries Research Institute, *FRI-UW-7808*, 124 pp., 1978.

Prespawning Mortality and the Reproductive Efficiency of Cedar River Sockeye Salmon, Q. J. Stober, S. Crumley, R. L. McComas, Supplememtal Completion Report for Matching Grant Project, OWRT Proj. B-065-WASH, OWRT Agreement No. 14-31-0001-6132, Washington Water Research Center, Seattle, Water Dept. and METRO, Univ. Washington, Fisheries Research Insitute, *FRI-UW-7809*, 53 pp., 1978.

UNIVERSITY OF WASHINGTON, Department of Civil Engineering, Seattle, Wash. 98195. Professor Neil M. Hawkins, Department Chairman.

159-10182-410-00

TIDAL INLET STUDIES

(*c*) Professor E. P. Richey or Professor R. E. Nece.
(*d*) Field investigation, basic research; Master's thesis.
(*e*) Field studies of the hydraulics of two half-tidal inlets on Puget Sound, Washington. Attention focused on stability of inlets across gravel beaches.
(*h*) **Hydraulics of Two Small Gravelly Tidal Inlets,** D. Simpson, *M.S. Thesis*, completed.
Changes in Beach Equilibrium Caused by a Backwater at a Small Tidal Inlet, A. Murray, *M.S. Thesis*, in process.

159-10183-470-13

MIXING AND FLUSHING CHARACTERISTICS OF SQUALICUM SMALL BOAT BASIN

(*b*) Dept. of the Army, Corps of Engineers, Seattle District.
(*c*) Professor E. P. Richey.
(*d*) Experimental, applied research; Master's thesis.
(*e*) Design of basin with regard to optimization of tidal flushing action and internal mixing.
(*f*) Completed.
(*h*) **Squalicum Small Boat Basin: Flushing Characteristics by Hydraulic Model,** E. P. Richey, N. H. Smith, *C. W. Harris Hydraulics Lab. Tech. Rept. No. 55*, Dec. 1977.

159-10189-810-00

ANALYSIS OF EXTREME HYDROLOGIC EVENTS

(*b*) Office of Water Research and Technology, U.S. Dept. of the Interior; Seattle Water Department; State of Washington Department of Ecology.
(*c*) Professor S. J. Burges.
(*d*) Theoretical numerical analysis.
(*e*) A linear programming formulation was used to determine the maximum (or minimum) probability associated with a given magnitude event subject to satisfying moments and a unimodal spline approximated density function. Extensive Monte Carlo studies are being conducted to determine the importance of uncertainty in small sample moments. Populations coefficient of variation and skews 0.6, 1.14; and 1.0, 2.0 respectively have been examined. Confidence bounds obtained by the method are comparable to those corresponding to the base distribution from which samples were derived.
(*h*) **A Linear Programming Approach to Estimating Probability Bounds for Extreme Flood Events,** J. O. Noetzelman, *M.S. Thesis*, 1976.
A Non-Parametric Approach to the Analysis of Extreme Hydrologic Events, D. P. Lettenmaier, S. J. Burges, *Proc. Intl. Symp. Risk and Reliability in Water Resources*, Univ. of Waterloo, Waterloo, Canada, pp. 853-872, 1978.

159-10193-810-33

IMPROVING RESERVOIR OPERATION THROUGH FORECASTING INTRASEASONAL SNOWMELT RUNOFF

(*b*) Office of Water Research and Technology; City of Seattle; State of Washington Department of Ecology.
(*c*) Professor S. J. Burges.
(*d*) Theoretical basic and applied research.
(*e*) The worth of a forecast is estimated by using a change constrained linear programming formulation of reservoir operation. Economic returns from forecasts having differing refinements are estimated. A model for obtaining conditional monthly flow distributions given a total seasonal runoff forecast was developed to provide relevant conditional distributions for the chance constrained model. Two types of total seasonal snowmelt runoff volume forecasts were used to determine which had greatest utility. A relatively simple model which extended the basic Tangborn model to choose when to incorporate snow course data proved to be quite effective. Attempts to calibrate and use the detailed snowmelt model used by the Sacramento Office of the National Weather Service were less successful. (Further work is being done with this model.)
(*f*) Completed.
(*h*) **Worth of Snow Course Data in Forecasting Snowmelt Runoff,** D. P. Lettenmaier, *Proc. Workshop/Mtg. Modeling of Snow Cover Runoff*, U.S. Army CRREL, Hanover, N.H., Sept. 1978.
Incorporation of Forecasted Total Seasonal Runoff Volumes Into Reservoir Management Strategies, K. Hoshi, S. J. Burges, *Proc. Intl. Symp. Risk and Reliability in Water Resources*, Univ. of Waterloo, Waterloo, Canada, pp. 853-872, 1978.
Incorporation of Forecasted Seasonal Runoff Volumes Into Reservoir Management, S. J. Burges, K. Hoshi, *Tech. Rept. 58*, Nov. 1978.
Forecasting Seasonal Snowmelt Runoff: A Summary of Experience With Two Models Applied to Three Cascade Mountain, Washington Drainages, D. P. Lettenmaier, T. J. Waddle, *Tech. Rept. No. 59*, 1978.

159-11186-470-13

FLUSHING CHARACTERISTICS OF SMALL BOAT BASINS IN TIDAL WATERS

(*b*) Department of the Army, Corps of Engineers, Portland District.
(*c*) Professor E. P. Richey.
(*d*) Experimental, applied research.
(*e*) Evaluation of flushing characteristics of a small boat basin located on an estuary.
(*f*) Completed.
(*h*) **Yaquina Bay Marina: Circulation and Exchange Characteristics,** E. P. Richey, N. K. Skjelbreia, *Technical Report No. 56*, Jan. 1978.

159-11187-470-13

FLUSHING CHARACTERISTICS OF SMALL BOAT BASINS IN TIDAL WATERS

(*b*) Washington State Department of Fisheries.
(*c*) Professor E. P. Richey or Professor R. E. Nece.
(*d*) Experimental, applied research.
(*e*) Evaluation of flushing characteristics by hydraulic model and field studies of Flounder Bay to provide input to water quality studies by Department of Fisheries to assess importance to fish and shellfish.
(*f*) In progress.

159-11188-430-00

FLOATING TIE BREAKWATER MODEL TESTS

(*c*) Professor R. E. Nece.
(*d*) Experimental; applied research; Master's thesis.
(*e*) Laboratory study to investigate scale effects on model test results of wave attenuation characteristics of floating tire breakwaters. Data from models of scale ratios 1:5 and 1:18 are compared with available prototype data; all data composed in the study are obtained with similar breakwater configurations tested for monochromatic waves under two-dimensional conditions in wave tanks.
(*f*) Completed.
(*h*) **An Investigation into the Scaling Confidence of Floating Tire Breakwater Model Tests,** W. L. Nelson, *M.S. Thesis*, 1978.

159-11189-350-65

TOLT RIVER DAM–HYDRAULIC MODEL STUDIES

(*b*) City of Seattle Engineering Department.
(*c*) Professor E. P. Richey or Professor R. E. Nece.
(*d*) Experimental; applied research–design.
(*e*) Physical model study to investigate the hydraulic capacity of a morning glory spillway and ring gate and to investigate the hydraulic behavior of the ring gate to determine the potential for flow problems which may be

created by lack of air vents, nappe instability, or other interactions between the water and other features of the ring gate-spillway structure as they exist at the prototype.

159-11190-470-36

EFFECTS OF PLANFORM GEOMETRY ON TIDAL FLUSHING AND MIXING IN MARINAS

(*b*) U.S. Environmental Protection Agency.
(*c*) Professor R. E. Nece or Professor E. P. Richey.
(*d*) Experimental; basic and applied research; Master's thesis.
(*e*) Laboratory study to determine, by quantitative measurements, the effects of particular geometry parameters upon both the overall (gross) water exchange rate and the spatial variability in local exchange rate due to tidal flushing in small-boat basins. Per-cycle exchange rates are determined by a photographic technique using a photo-densitometer.

159-11191-300-60

CALIBRATION OF EQUATIONS FOR PREDICTING VELOCITY DISTRIBUTION IN A RIVER FOR INSTREAM FLOW ANALYSIS

(*b*) State of Washington Water Research Center.
(*c*) Professor R. E. Nece.
(*d*) Field investigation; applied research; Master's thesis.
(*e*) Specific objective is to certify and calibrate three variations of an analytical procedure which has been proposed for the prediction of velocity distributions in natural streams for flows at which velocities have not been measured. Data used in the verification and calibration procedures will be obtained from detailed field experiments at appropriate sites on rivers in western Washington State.

159-11192-800-33

WATER RESOURCE SYSTEM OPERATION AND DESIGN FOR DROUGHT CONDITIONS

(*b*) Office of Water Research and Technology, U.S. Dept. of the Interior; Seattle Water Department; State of Washington Department of Ecology.
(*c*) Professor S. J. Burges.
(*d*) Theoretical basic and applied research.
(*e*) Determine (1) how the risk associated with alternate operating policies for use during conditions of supply shortfalls can be assessed; (2) how long-range meteorological forecasts can be incorporated into system operation under drought conditions; and (3) how drought indices can be used to determine when a facility should switch to alternate policies developed under (1) and when operation should revert to the normal (no supply shortfall) policy.

159-11193-470-65

FLUSHING CHARACTERISTICS OF SMALL BOAT BASINS IN TIDAL WATERS

(*b*) Port of Olympia, Olympia, Washington.
(*c*) Professor E. P. Richey or Professor R. E. Nece.
(*d*) Experimental, applied and basic research; Master's thesis.
(*e*) Evaluation of flushing characteristics by hydraulic model of alternative marina designs; development of simplified, one-dimensional dispersion model.
(*f*) Completed.
(*h*) **Flushing and Mixing Characteristics East Bay Small Boat Basin,** E. P. Richey, R. E. Nece, *C. W. Harris Hydraulics Laboratory Tech. Rept. No. 50*, July 1977.
Olympias East Bay Small Boat Basin: Comparative Hydraulic Model Techniques for Evaluating Tidal Flushing, K. David Moss, *M.S. Thesis*, 1978.

159-11194-810-33

THE FEASIBILITY OF IMPLEMENTING A CONTINUOUS SIMULATION HYDROLOGIC MODEL FOR URBAN DRAINAGE SYSTEM DESIGN

(*b*) Office of Water Research and Technology, U.S. Dept. of the Interior.
(*c*) Professor S. J. Burges.
(*d*) Applied Research.
(*e*) See (g).
(*f*) Completed.
(*g*) Attention has been focused recently on management of urban runoff as one means of protecting water quality. Experience gained during Area-wide Waste Management planning in King and Snohomish Counties (Washington) has shown that analytical methods currently in use are generally inadequate for comprehensive and reliable watershed analysis. The modeling needs and desires of several potential model users in the two Counties, and their perceptions of models, are identified through personal interviews. The literature is reviewed for the perceptions of professional modelers; these are compared with those of the potential users. Inconsistencies are noted and resolved. Criteria for evaluating continuous simulation models for local use are developed. Variations of the Stanford Watershed Model (SWM) are the only models having the desired characteristics and are evaluated as a group in detail. It is concluded that the SWM can provide better information than more commonly used methods. The primary model limitations are its demands for data, particularly rainfall records, and the cost associated with data development and handling. A system of data development in conjunction with establishment of watershed planning priorities is suggested. The recommendations for use of the Continuous Simulation approach are not limited to the two counties examined here.
(*h*) **Hydrologic Modeling and Data Requirements for Analysis of Urban Streamflow Management Alternatives,** G. J. Kemp, S. J. Burges, *Technical Report 57*, Nov. 1978.

159-11195-810-00

CLIMATE CHANGE: DETECTION AND ITS IMPACT ON HYDROLOGIC DESIGN

(*c*) Professor S. J. Burges.
(*d*) Theoretical basic research.
(*e*) See (g).
(*f*) Completed.
(*g*) Controversy regarding origins of the so-called Hurst phenomenon has continued since the first appearance of Hurst's work. There appears to be at least two general mechanisms which might generate geophysical time series displaying the Hurst phenomenon. The first is nonstationarity of process mean level, perhaps owing to dynamic characteristics of the entire earth geophysical system. The second generating mechanism is a stationary model structure such as the Box Jenkins models with parameters such that saubstantial low-frequency effects are present. A series of Monte Carlo tests have been performed which show that it will generally be very difficult to distinguish between the two generating mechanisms on the basis of geophysical records of lengths usually available. The Monte Carlo experiments are augmented by analysis of several series of tree ring growth indices ranging in length from 506 to 1164 years. Analysis of these sequences for nonstationarity in mean level showed that the sequences were entirely compatible with stationary Bob-Jenkins models earlier fit to the data by Hipel (1975). However, a similar analysis of the variance of the time series showed that there was evidence of nonstationarity in the variances of the records such that the time series were not compatible with the constant variance assumption of the stationary Box-Jenkins models. Finally, several reservoir simulations were made by using the sequent peak algorithm for type A (nonstationary mean) and type B (constant mean) models which had been found to be statistically indistinguishable in the Monte Carlo experiments. The results showed that so long as nonstationarity in mean level was modest and demand levels were not too high the models give very similar results; however, at high demand levels or large nonstationarity in process mean, substantial differences in storage requirements may result.
(*h*) **Climate Change: Detection and Its Impact on Hydrologic Design,** D. P. Lettenmaier, S. J. Burges, *Water Resources Research* **14**, 4, pp. 679-687, 1978.

159-11196-810-33

DISAGGREGATION METHOD IN STOCHASTIC HYDROLOGY

(*b*) Partly supported by Office of Water Research and Technology, U.S. Dept. of the Interior.
(*c*) Professor S. J. Burges.
(*d*) Theoretical basic research and applied research.
(*e*) A disaggregation model, which differs from those developed by Valencia and Schaake (VS) and Mejia and Rouselle (MR) (referred to as the HB model), was developed specifically to preserve correlations between seasons joining water years in addition to the properties preserved by the basic VS model. The HB model simultaneously disaggregates two consecutive skewed seasonal flows that follow three-parameter log-normal distributions (3PLN). Mixtures of skewed and nonskewed seasonal flow volumes are approximated by 3PLN distributions for operational convenience. Practical considerations concerning use of these models for multisite flow disaggregation are reviewed together with computational space requirements and limitations on model computability. A HB 3PLN model for single-site flow disaggregation is used in an example application where comparisons are made with the MR model. Comparisons have been made using disaggregation models with skewed and unskewed monthly (or seasonal) flow volumes to examine the importance of modeling skew. The impacts of long-term memory (Hurst effect) are demonstrated as are limitations of a simple Thomas-Fiering Model.
(*f*) Completed.
(*h*) **Disaggregation of Streamflow Volumes,** K. Hoshi, S J. Burges, *J. Hydraulics Div., ASCE* **105,** HY4, pp. 27-42, 1979.
The Impact of Seasonal Flow Characteristics and Demand Patterns on Required Reservoir Storage, K. Hoshi, S. J. Burges, *J. Hydrology* **37,** pp. 241-260, 1978.
Reservoir Design Capacities for Various Seasonal Operational Hydrology Models, K. Hoshi, S. J. Burges, I. Yamaoka, *Proc. Japan Soc. Civil Engr.*, No. 273, pp. 121-134, 1978.

159-11197-860-60

USE OF SURFACE AND CYCLIC GROUNDWATER STORAGE SYSTEMS FOR WATER RESOURCE DEVELOPMENT

(*b*) State of Washington Water Research Center.
(*c*) Dennis P. Lettenmaier, Research Asst. Professor.
(*d*) Theoretical basic research.
(*e*) Monte Carlo study of hypothetical single surface reservoir and aquifer storage to be operated to meet a range of fixed physical water demands. Objective is to develop best mixes of surface and subsurface storage using a minimum expected supply cost criterion.

159-11198-810-55

USE OF THE THEORY OF REGIONALIZED VARIABLES IN HYDROLOGIC NETWORK DESIGN

(*b*) U.S. Nuclear Regulatory Commission.
(*c*) Dennis P. Lettenmaier, Research Asst. Professor.
(*d*) Theoretical basic research (M.S.).
(*e*) Theoretical study of alternate estimation methods based on the theory of regionalized variables. Application to design of water quality sampling program for assessment of environmental impact of power plants sited on lakes and reservoirs is being investigated.

159-11199-740-00

DETERMINATION OF BIAS CORRECTION FACTORS FOR USE IN ESTIMATION OF THE PARAMETERS OF THE LOG PEARSON TYPE III PROBABILITY DISTRIBUTION

(*c*) Dennis P. Lettenmaier, Research Asst. Professor.
(*d*) Theoretical applied.
(*e*) Bias correction factors for application in estimation of the parameters of the Log Pearson Type III probability distribution, commonly used in U.S. Flood studies, are estimated via Monte Carlo methods.
(*f*) Completed.
(*g*) Bias correction factors of both greater and less than one were observed, in contrast to factors greater than unity found for other distributions commonly used in flood studies.

159-11200-740-55

APPLICATION OF INTERVENTION ANALYSIS TO AQUATIC ENVIRONMENTAL IMPACT ASSESSMENT

(*b*) U.S. Nuclear Regulatory Commission.
(*c*) Dennis P. Lettenmaier, Research Asst. Professor.
(*d*) Theoretical applied.
(*e*) A method for applying intervention analysis, a time series technique for assessing changes in the mean of an autoregressive integrated moving average process is developed for the case when some observations are missing.
(*f*) Completed.
(*g*) Satisfactory results were obtained using the method for several mean functions with residual lag one autoregressive noise for up to one-half of the data missing.
(*h*) **Assessment of Environmental Impacts, Part II: Data Collection,** D. P. Lettenmaier, K. W. Hipel, A. I. McLeod, *Environmental Management* **2,** No. 6, pp. 537-554, 1978.

159-11201-740-54

ESTIMATION OF MASS BALANCE ERRORS USING FIRST ORDER ANALYSIS

(*b*) National Science Foundation.
(*c*) Dennis P. Lettenmaier, Research Asst. Professor.
(*d*) Theoretical applied.
(*e*) A method of estimating the error variance in the components of seasonal or annual lake nutrient budgets is developed which makes use of first order analysis. Individual terms in the mass balance are taken to be derived from field measurements with associated estimation error. The effect of the individual errors on the residual mass balance error is also determined. The variance of the residual error is used as the basis for comparing alternate sample networks.
(*f*) Completed.
(*h*) **Use of First Order Analysis in Estimating Mass Balance Errors and Planning Sampling Activities,** D. P. Lettenmaier, J. E. Richey, Chapter 3 in *Theoretical Systems Ecology*, (E. Halfon, ed.), Academic Press, N.Y., 1979.

UNIVERSITY OF WASHINGTON, Department of Mechanical Engineering, Seattle, Wash. 98195. Dr. Morris E. Childs, Chairman.

161-10072-700-40

FLUID DYNAMIC MEASUREMENTS UTILIZING PULSED ULTRASONIC DOPPLER TECHNIQUES

(*b*) National Institute of Health (NIH).
(*c*) Research Asst. Professor Fred K. Forster.
(*d*) Theoretical and experimental applied research including Ph.D. dissertation.
(*e*) Analytical modeling of ultrasonic Doppler system and basic fluid dynamic experiments are utilized to develop a better understanding of velocity measurements mode with pulsed ultrasonic methods, in particular pulsatile and turbulent flow. To date turbulent pipe flow and grid turbulence have been studied. The aim of this work is quantitative noninvasive measurements of blood flow characteristics in humans.
(*g*) Results are being applied clinically to detect flow disturbances due to atherosclerotic occlusions in arteries.
(*h*) **The Applications and Limitations of Doppler Spectral Broadening for the Detection of Cardiovascular Disorders,** F. K. Forster, *Ultrasound in Medicine* **3B,** pp. 1223-1226.

Measurement of Fluid Turbulence Based on Pulsed Ultrasound Techniques, J. L. Garbini, *Ph.D. Dissertation*, Dept. Mechanical Engrg., Univ. of Washington. Available from University Microfilms, Ann Arbor Michigan.

Doppler Principles and Techniques, D. W. Baker, F. K. Forster, R Daigle, *Ultrasound: Its Application in Medicine and Biology, Part I, Vol. 3 of Methods and Phenomena: Their Applications in Science and Technology*, Francis Fry, ed., Elsevier Publishing Co., pp. 161-287, 1978.

Quantitative Flow Measurement Utilizing a Time Interval Histogram of Doppler Shifted Ultrasound, *Ultrasound in Medicine*, **4,** D. White and E. A. Lyons, eds., Plenum Press, pp. 349-353, 1978.

Fluid Flow Measurement with Doppler Ultrasound, F. K. Forster, *Engineering Education* **69,** No. 1, p. 44, 1978 (abstract).

Blood Flow Imaging Using a Discretetime Frequency Analyzer, M. A. Brandestini, F. K. Forster, *1978 Ultrasonics Symp. Proc. (IEEE Cat. 78CH 1344-1 SU)*, pp. 348-352, 1978.

Numerical Method for Analyzing a New Time Domain Frequency Analyzer for Ultrasonic Doppler Signals, F. K. Forster, M. A. Brandestini, *1978 Advances in Bioengineering*, R. C. Eberhart and A. H. Burstein, eds., ASMe, pp. 113-115, 1978.

UNIVERSITY OF WASHINGTON, Department of Oceanography, Seattle, Wash. 98195. Dr. D. James Baker, Jr., Department Chairman.

162-07779-060-26

SHEAR FLOW EFFECTS IN CONSTANT DENSITY AND STRATIFIED FLUIDS

(*b*) Air Force Office of Scientific Research.
(*c*) Professor William O. Criminale, Jr.
(*d*) Theoretical; basic research.
(*e*) Studies include interaction of shear flow and internal waves; initial value problems at the thermocline and Ekman layer; turbulence in stratified media; wave breaking; large scale boundary layers, boundary layer stability.
(*g*) Linearized analysis for all of the above (e).
(*h*) **On Breaking of Internal Gravity Waves,** *Paper No. 5, Proc. Intl. Symp. of Stratified Flow*, Novosibirsk, USSR, Aug. 1972.

On the Asymptotic Structure of Turbulent Transfer Coefficients, *Zeitschrift fur Angewandte Mathematik and Mechanik* **55,** 291-289, 1975.

Resonant Interaction of Internal Waves in Linear Shear Flow, K. F. Jones, *M.S. Thesis*, Geophysics Group, Univ. of Washington, 1974.

Fluctuations and Structure Within the Oceanic Boundary Layer Below the Arctic Ice Cover, W. O. Criminale, Jr., G. F. Spooner, *AIDJEX Bulletin*, No. 30, 29-43, Nov. 1975.

Wave Breakdown in Stratified Shear Flows, M. T. Landahl, W. O. Criminale, Jr., *J. Fluid Mechanics* **79,** 3, 481-477, 1977.

Mass Driven Fluctuations within the Ekman Boundary Layer Bottom Turbulence, (J. C. J. Nihoul, ed.).

Instabilities in a Rotating Fluid with Constant Shear, W. O. Criminale, Jr., T. F. Gross, submitted to J. Geophysical Research.

162-11202-450-54

STUDIES IN MARINE HYDRODYNAMICS

(*b*) National Science Foundation.
(*c*) Professor M. Rattray, Jr.
(*d*) Theoretical, basic research.
(*e*) A sequence of studies on basic dyamics of oceans and estuaries: the effect upon baroclinicity of an ocean by the extent to which its western boundary current flows over a region of limited depth and the impact of this effect upon the heat balance of the ocean; processes that govern the deep ocean circulation, with emphasis on the cause for the amount of compensation which occurs and on the presence of localized strong currents; comparison of computed geostrophic velocity distributions by two methods, diagnostic circulation (Rattray-Dworski) and β-spiral method (Schott-Stommel); the effect of variable depth over an estuarine cross-section on the distributions of current, salinity and other tracers; the processes which control the longitudinal fluxes of salt and other properties; the effect of channel curvature in setting up residual currents (due to tidal pumping) and other secondary circulations; the role these processes play in the overall salt balance of the estuary.
(*h*) **The Effect of Bathymetry on the Steady Baroclinic Ocean Circulation, (with J. G. Dworski),** ***Ocean Modelling*** **12,** Aug. 1978.

The Effect of Bathymetry on the Steady Baroclinic Ocean Circulation, (with J. G. Dworski), *Dynamics of Atmospheres and Oceans* **2,** 4, pp. 321-329, Aug. 1978.

Distribution of a Nonconservative Constituent in an Estuary with Application to the Numerical Simulation of Dissolved Silica in the San Francisco Bay, (with C. B. Officer), *Estuarine and Coastal Marine Science*, 8, (in press) 1979.

Salt Flux and Mixing in the Columbia River Estuary, (with F. H. Hughes), submitted to: *Estuarine and Coastal Marine Science*, Mar. 1979.

162-11203-410-44

INVESTIGATION OF SEDIMENT TRANSPORT IN THE NEARSHORE ENVIRONMENT

(*b*) Office of Sea Grant, NOAA, U.S. Department of Commerce.
(*c*) Professor Richard W. Sternberg.
(*d*) Field investigation, basic research, Doctoral dissertation.
(*e*) The overall objectives of the research carried out by the Sediment Dynamics Group at the University of Washington are twofold. First, it is our intent to make a significant contribution to the National Sediment Transport Study (NSTS) program plan. These data will be acquired during a joint large-scale experiment with Scripps Institution of Oceanography and the Naval Postgraduate School to be conducted at Santa Barbara, California in 1979. Secondly we intend to assist other NSTS participants in the data processing and analysis that is necessary to accomplish the major NSTS program goal which is to develop a general model for the prediction of sediment transport along straight beaches.
(*g*) The instrument development is near completion. Initial field data have been collected and analysis is underway.
(*h*) **Sediment Transport Measurement in the Nearshore Environment: A Review of the State of the Art,** J. P. Downing, Jr., *Sea Grant Publication No. 62*, pp. 58-83, Univ. California, Sea Grant College Program, Inst. of Marine Resources, Univ. of California, La Jolla, *IMR Reference 78-102*.

162-11204-410-54

SHELF SEDIMENT DYNAMICS PROGRAM: PRELIMINARY PHASE

(*b*) National Science Foundation, IDOE Office.
(*c*) Professor Richard W. Sternberg.
(*d*) Theoretical, experimental, and field phases of research are proposed.
(*e*) As an outgrowth of the *Shelf Sediment Dynamics Workshop* held at Vail, Colorado, 1976, under the primary sponsorship of IDOE, a long-range study of continental shelf sediment dynamics has been proposed. The scientific goals of the proposed program include the theoretical and quantitative investigation of modern sedimentary processes, quantification of depositional facies development with applications for interpreting the sedimentary record, and the recent geological history of continental shelves. The goals of the program not only possess intrinsic scientific value

but also have vital applications for the practical matters of resource and environmental management. A quantitative approach in the form of an integrated model is proposed. The model framework consists of five scientific components: (1) shelf sedimentology and stratigraphy, (2) physical oceanography, (3) sediment transport mechanics, (4) sediment-organism interactions, (5) near-bottom flow and sediment transport. The outputs of the sedimentation model are multifold. Each component is an important research effort in its own right and will produce independent scientific results pertaining to shelf sedimentary processes. In addition, the interaction of components will broaden the scope of the study–providing results applicable to the geological record.

(*g*) A scientific proposal based on the inputs of participatory scientists is being prepared and will request a 1980 starting date.

162-11205-220-54

MECHANICS OF SEDIMENT TRANSPORT IN RIVER MEANDERS

(*b*) National Science Foundation.
(*c*) Professor J. Dungan Smith and Professor Thomas Dunne.
(*d*) Theoretical, field; basic research.
(*e*) Studies include examination of a meander in a small river using measurements of a precision usually attained in laboratories but hitherto not attempted under natural conditions; investigation of general helicoidal flow in light of available fluid mechanical theories; examination of the near bottom velocity field as it is affected by large scale channel topography and bed forms; measurement of the sediment transport rates relation to the boundary shear stress field, investigation of the relationship between sediment transport and channel morphology and finally construction of a theoretical model that will encompass these facets of the flow in bends and provide a means of predicing sediment transport fields in rivers.
(*g*) Bedforms strongly dictate the path of sediment through a bend. The asymmetrical distribution of boundary shear stress in a meander causes sand waves to become aligned obliquely to the flow which induces a troughwise current capable of transporting significant amounts of sediment. In the upstream part of the bend there is net cross stream transport of sediment towards the inside bank which contributes to the development and maintenance of the pool. The near bottom flow pattern imposes a cross-iso bath zigzag trajectory on the sediment grains and is responsible for sorting the bed material.
(*h*) **Flow and Sediment Transport in a Meandering River,** (with W. E. Dietrich and T. Dunne), *J. Geology*, 1979 (in press).

162-11206-010-54

TIME DEPENDENT TURBULENT BOUNDARY LAYERS IN TIDAL FLOWS

(*b*) National Science Foundation.
(*c*) Research Asst. Professor Arthur R. M. Nowell.
(*d*) Field; basic research.
(*e*) Studies include measurements of the velocity and Reynolds stress fields with small impellor meters to test the assumption of a uniform stress layer; evaluation of stress from the energy dissipation rate; turbulence and high frequency velocity fluctuation measurements.
(*g*) Preliminary investigations at the field site (Skagit Bay) were undertaken in December 1978. Detailed profiles of bed topography at and around the site were constructed, and the large scale structure of the flow was examined. This will provide the necessary morphological and fluid dynamic setting for the comprehensive measurement program.

162-11207-400-54

TURBULENT MIXING IN ESTUARINE WATERS

(*b*) National Science Foundation.
(*c*) Professor J. Dungan Smith.
(*d*) Theoretical, field investigation; basic research.
(*e*) Project is concerned with the mixing processes in highly stratified estuaries. Work on the Duwamish River involves analysis of mean vorticity, turbulent kinetic energy, and salinity data procured in March 1977. The Knight Inlet study involves examination of turbulence and nonlinear internal waves produced over a sill. Emphasis is presently being placed on examining these processes as they are made evident in a comprehensive set of data procured in August 1977 and on an extensive experiment which focuses on the mechanics of an internal hydraulic jump produced at the sill and on the resulting turbulence field.
(*g*) It has been found that internal hydraulic processes, including the production and dissipation of nonlinear internal waves, are of critical importance. Entrainment of seawater into the surface layer of the Duwamish River has been found to occur impulsively during the ebb. At this time the reach of the estuary in which the mixing occurs approaches the critical internal Froude number and the internal wave field grows in amplitude until it produces sufficient turbulence to destabilize the pycnocline, causing the surface layer to rise rapdily in salinity and deepen. Internal hydraulic processes in Knight Inlet are of a different character in that the primary mixing events occur at an inner sill around which several types of flow instabilities are found.
(*h*) **Time Dependent Mixing in a Salt Wedge Estuary,** (with E. N. Partch), *Estuarine and Coastal Marine Science* **6**, No. 1, pp. 3-19, 1978.
Nonlinear Internal Waves in a Fjord, (with D. Farmer), *Hydrodynamics of Estuaries and Fjords*, edited by J. C. J. Nihoul, Elsevier Scientific Publ. Co., pp. 79-106, 1978.
Turbulent Mixing in a Salt Wedge Estuary, (with G. B. Gardner), *Hydrodynamics of Estuaries and Fjords*, edited by J. C. J. Nihoul, Elsevier Scientific Publ. Co., pp. 79-106, 1978.

WATER RESOURCES ENGINEERS, 8001 Forbes Place, Springfield, Va. 22151.

163-11212-810-68

HYDROLOGIC MODELING STUDY FOR SOUTHEAST MICHIGAN

(*b*) Southeast Michigan Council of Governments.
(*c*) Dr. L. A. Roesner, P. E., and Mr. J. W. Ridgway.
(*d*) Analytical; applied research.
(*e*) A single event runoff model was developed capable of simulating both conservative and nonconservative pollutants. The model, which generates runoff from up to 12 land uses plus the attendant pollution load, was applied to the Rouge River which encompasses much of the Detroit Metropolitan area. The calibrated simulation included instream reservoirs, double trapezoidal channels and a combined sewer area. The calibration ranged from fair to excellent.
(*f*) Completed.
(*g*) The study and associated modeling effort clarified and better defined the water quality problems in Southeast Michigan. In addition, several planning directives resulted directly from this modeling effort.

WEBB INSTITUTE OF NAVAL ARCHITECTURE, Crescent Beach Road, Glen Cove, N. Y. 11542. Dr. Jacques B. Hadler, Director of Research.

164-11213-520-45

DEVELOPMENT OF EXPERIMENTAL MEANS OF ASSESSING AND OPTIMIZING FOR REDUCING WAVE PRODUCTION POWER OF SHIPS

(*b*) U.S. Department of Commerce Maritime Administration University Research Program.
(*c*) Professor Lawrence W. Ward.
(*d*) Experimental: basic research.

(*e*) Improve and use as a working tool, an experimental method for optimizing the resistance of commercial ship type hull form at speeds where wavemaking is important. The method will combine an established wave-survey experimental technique with an on-line computer data analysis to accomplish the desired result. The approach is therefore a combined experimental and analytical one. The exact type of hull to start with to be investigated in the model experiments will be one already optimized using the linear theory. Next hull form variations will be studied based on analysis of these results. An experimental determination would be carried out with respect to some standard protuberance placed at different locations, horizontally and vertically, along the hull to predict the optimum size and location of such further hull form changes. A protuberance is considered to be a bulge on the port and starboard side of the hull, each with a shape similar to half a bow bulb; thus, a bow bulb is included in this definition as a protuberance located at the stem, where the hull form has zero width.
(*g*) In process, no specific results as of yet.

164-11214-520-84

PREDICTING RESISTANCE INCREASE FROM SURFACE ROUGHNESS

(*b*) Society of Naval Architects and Marine Engineers.
(*c*) Professor N. A. Hamlin.
(*d*) Theoretical; applied research and development.
(*e*) Estimation of potential flow and boundary layer characteristics on a surface ship. Determination of effect on resistance of drags resulting from arbitrary roughnesses, arbitrarily distributed. Estimation of effect of resistance increase on propeller horsepower and RPM. Emphasis on methodology, using available published information.
(*g*) Correlations between two- and three-dimensional potential flows past bodies of revolution have been determined as an aid to estimating potential flow past ship forms on the basis of two-dimensional flows.

164-11215-520-45

DEVELOPMENT OF AN ANALYTICAL MODEL FOR HULL PERFORMANCE ASSESSMENTS

(*b*) Subcontracted to Webb Institute Center for Maritime Studies by Santa Fe Corp., sponsored by Mar Ad.
(*c*) Professor J. B. Hadler, Director of Research.
(*d*) Theoretical and field; applied research and development.
(*e*) Goal of project is to determine economic effect on merchant ship performance of bottom roughness and fouling, and its growth with time, thereby enabling a ship operator to optimize dry docking intervals, and bottom cleaning and coating techniques.
(*g*) Increases in roughness allowance ΔC_f and wake fraction have been determined for two break bulk merchant ships by analysis of log book data covering several dry docking and recoating cycles. Methodology assumes ship operating at constant power and in fair weather during several days of ocean leg of each voyage. It is also assumed that turbine performance charts may be applied during these periods to find shaft horsepower.

WESTERN WASHINGTON UNIVERSITY, Department of Geography and Regional Planning, Bellingham, Wash. 98225. Dr. Thomas A. Terich.

165-11216-410-60

PUGET SOUND SHORE EROSION PROTECTION STUDY

(*b*) Department of Ecology, State of Washington.
(*c*) T. A. Terich.
(*d*) Field investigation, applied research.
(*e*) The study explains some of the basic dynamics of shoreline processes in Puget Sound and illustrates some of the structural and non-structural techniques private property owners may use to combat shoreline erosion. In addition, an explanation is given of local, state, and federal agencies that have jurisdiction over the shoreline and permit programs administered by each.
(*f*) Completed.
(*h*) **Puget Sound Erosion Protection Study**, T. A. Terich, Dept. of Ecology, State of Washington, 78-11, pp. 55 (1978).

WESTINGHOUSE ELECTRIC CORPORATION, Oceanic Division, P.O. Box 1488, Annapolis, Md. 21404.

166-08399-700-00

GAUSSIAN INTEGRATION APPLIED TO ULTRASONIC TECHNIQUE OF VOLUMETRIC FLOW MEASUREMENT

(*c*) R. L. Hackmann–Manager, Applied Technology/M/S 9R30.
(*d*) Theoretical and experimental applied research.
(*e*) Evaluate the accuracy with which volumetric flow can be determined by summing appropriately weighted measurements derived from transit times of ultrasonic pulses. Transducers are arranged so that the measurements establish mean flow velocity over parallel paths lying in a plane at a known angle to the axis of the conveyance. Path spacings and weighting factors are selected according to the Gaussian technique of numerical integration. A part of the investigation includes the calculation of integration errors for various velocity distributions in pipes of circular or rectangular cross-section. Experiments have been conducted to verify the integration error for fully developed turbulent flow in a straight pipe, and to evaluate the errors encountered in installations involving substantial hydraulic complexity which cannot be predicted with high accuracy. The experiments employed a weigh tank facility as a flow measurement standard. Experiments extend to the evaluation of single acoustic path flow measurement techniques as well as multi-path techniques.
(*g*) The experimental results show that overall accuracy of 0.1 percent in the measurement of fully-developed flow in straight pipe is achievable when the predicted small error in Gaussian integration is corrected. Tests in the outlet piping of a heat exchanger model indicate an error slightly greater than one percent at the least favorable orientation of the measurement plane. Choosing a better orientation and/or correcting the residual systematic error makes possible overall accuracy well within one percent in this case.
(*h*) **Ultrasonic Flowmeter Nucleus of Unique Leak Detection System,** E. S. Chaney, B. L. Johnston, *Pipeline and Gas Journal*, Oct. 1976.

WEST VIRGINIA UNIVERSITY, Department of Mechanical Engineering and Mechanics, Morgantown, W. Va. 26506. Dr. E. F. Byars, Department Chairman.

167-10016-700-54

PULSATILE FLOW THROUGH AN ORIFICE

(*b*) National Science Foundation.
(*c*) R. A. Bajura.
(*d*) Experimental and theoretical; basic research; M.S. and Ph.D. theses.
(*e*) The flow and pressure fields in the neighborhood of a standard flow metering orifice were studied experimentally to determine the details of the flow field in both steady and pulsatile flow conditions. Weigh tank calibrations of water flow rates through the orifice under pulsatile flow were performed for the purpose of determining the flow metering error. An analytical model of the flow through the orifice was developed for flow metering purposes.
(*f*) Completed.
(*g*) Steady flow methods predict more discharge through the orifice than actually occurs under pulsatile flow conditions.

(*h*) **Pulsatile Flow Through An Orifice–Final Report,** R. A. Bajura, et al., *NTIS Accession Number PB292194/AS,* 1979.

167-10017-060-33

INFLUENCE OF PUMPED STORAGE FLOWS ON THERMAL STRATIFICATION IN RESERVOIRS

(*b*) Office of Water Research and Technology.
(*c*) R. A. Bajura and S. H. Schwartz.
(*d*) Experimental, M.S. theses.
(*e*) Determine procedures for distortion modeling of pumped storage reservoir systems and determine the influence of the discharge and withdrawal cycles on thermal stratification and mixing.
(*f*) Completed.
(*h*) **Influence of Pumped Storage Flows on Thermal Stratification in Reservoirs,** V. Singh, R. A. Bajura, S. H. Schwartz, *Final Report,* Mech. Engrg. Dept., West Virginia Univ., 1979 (to be submitted to NTIS).

167-10019-210-60

PULVERIZED COAL TRANSPORT MANIFOLD DESIGN STUDY

(*b*) State of West Virginia.
(*c*) R. A. Bajura.
(*d*) Theoretical, M.S. thesis.
(*e*) Determine design methods for the prediction of flow distribution in manifold systems transporting pulverized coal in water slurries or air/coal suspensions.
(*f*) Completed.
(*h*) **Analytical Study of Manifold Flow Distribution Systems for Pulverized Coal Slurries,** M. Kabariti, R. A Bajura, T. Kubo, Mechanical Engrg., West Virginia Univ., 1977.

167-11216-750-10

EFFECTS OF GEOMETRIC SCALE DISTORTION ON THE CHARACTERISTICS OF SUBMERGED BUOYANT JETS

(*b*) U.S. Army Engineer Waterways Experiment Station.
(*c*) R. A. Bajura.
(*d*) Experimental and analytical, Ph.D. thesis.
(*e*) Develop correlations and procedures to enable accurate thermal-hydraulic studies to be conducted in experimental models using different length scales for horizontal and vertical directions.

UNIVERSITY OF WISCONSIN-MADISON, Department of Civil and Environmental Engineering, Madison, Wis. 53706. Professor T. Green.

168-10026-220-50

VERTICAL TRANSPORT OF SEDIMENT DUE TO FINGERING PROCESSES

(*b*) NASA
(*d*) Experimental, field work; basic research; Masters thesis.
(*e*) Sediment fingering, analogous to *salt fingering* in the ocean, is being studied in both the laboratory and in small lakes during spring runoff.

168-11217-340-50

OCCURRENCE, CHARACTERISTICS AND MECHANICS OF THERMAL FRONTS IN CONDENSER COOLING WATER DISCHARGES

(*b*) NASA.
(*c*) Professor John A. Hoopes.
(*d*) Experimental, theoretical; basic research; Doctoral thesis.
(*e*) Thermal fronts which occur in heated water discharges into water bodies are manifested by alternating bands of warm and cool water (3-4 °C differences) which extend over the discharge depth and propagate into the ambient water body. Laboratory experiments are being conducted to generate and measure the characteristics of these fronts; point measurements of temperature and velocity with probes and surface temperature measruements with a thermal scannner are being made. Correlation and spectral analysis methods are being used to determine front characteristics. Hydrodynamic stability methods are used to study the initiation and growth of the fronts; a one-dimensional wave model is used to simulate the fully-developed front propagation.

168-11218-860-68

RATE OF NITROGEN RELEASE FROM NITROGEN SUPERSATURATED RIVER FLOWS

(*c*) Professors John A. Hoopes and Lawrence B. Polkowski.
(*d*) Experimental; basic research; Master's project.
(*e*) Laboratory studies in a mixing tank and a flume are being conducted to determine the rate at which water, supersaturated with nitrogen gas, returns to equilibrium. The effects of turbulence level and flow velocity and depth on the rate process will be determined.

168-11219-810-70

MONITORING AND MODELING OF HYDROLOGY OF NEPCO LAKE WATERSHED

(*b*) Nekoosa Edwards Paper Company (NEPCO), Nekoosa, Wisconsin.
(*c*) Professor John A. Hoopes.
(*d*) Field investigation; applied research, operation; Master's projects.
(*e*) The surface and groundwater hydrology of the 175 mi^2 NEPCO Lake Watershed in the central sand plains area were monitored for several years. The U.S. Army corps SSARR hydrologic model was modified and adapted to the watershed for predicting flows to NEPCO Lake at the watershed outlet.
(*f*) Completed.
(*g*) Monitoring data included stream and irrigation ditch flows at various locations in the watershed, water table elevations and aquifer properties, precipitation, and lake stage. The SSARR model was modified to include irrigation and a more refined evapo-transpiration model, was calibrated and tested using monitoring data, and was used to assess the effects of land use changes on surface and groundwater flows to NEPCO Lake.

168-11220-810-50

WATER AND SOIL RUNOFF FROM HYDROLOGIC SOURCE AREAS IN A WATERSHED

(*c*) Professor John A. Hoopes.
(*d*) Field; apllied research; Master's project.
(*e*) Remote sensing (aerial photography) in conjunction with ground data (sampling, soil surveys, topography and land use) was used to delineate water and sediment runoff from a subbasin of the Pheasant Branch watershed.
(*f*) Completed.
(*g*) Precipitation, overland flow, soil moisture and sediment yield data for several storms along with basin physiography were collected on a 36 acre watershed, which is largely agricultural. The data were compared with soil and water loss estimates using a numerical model and SCS methods. Color aerial photographs were examined to delineate hydrologic source areas.

168-11221-200-54

VELOCITY DISTRIBUTION AND VERTICAL DIFFUSION COEFFICIENT IN FLOW THROUGH AQUATIC PLANTS

(*b*) NSF–IBP.
(*c*) Professor John A. Hoopes.
(*d*) Experimental, field work; basic research; Master's project.
(*e*) Measurements were made of the vertical distribution of the horizontal velocity and of the vertical turbulent diffusion coefficient, using a thermal velometer and salt (or dye) tracers, in flow through a laboratory flume with rooted macrophytes extending over the flow depth and in the littoral zone of a small lake having rooted macrophytes.

(*f*) Completed.
(*g*) Results showed that the presence of aquatic plants increased turbulence levels, compared to a flow without plants (other flow conditions being the same), and lead to a more uniform vertical distribution of horizontal velocity and an increased vertical diffusion coefficient.

168-11222-200-60

OPTIMAL CROSS-SECTION SPACING IN GRADUALLY VARIED OPEN CHANNEL FLOW COMPUTATION

(*b*) Wisconsin Department of Natural Resources.
(*c*) Professor P. L. Monkmeyer.
(*d*) Theoretical; applied research; Master's thesis.
(*e*) The purpose of this study is to determine the optimal spacing of cross-sections in the computation of gradually varied flow in open channnels. Specifically, a general relation is being sought between cross-section spacing and percent error in predicted water surface elevations, with particular emphasis on the effect of the method used to determine the average friction slope.

168-11223-420-44

AN ELECTRONIC MODEL OF HARBOR WAVES

(*b*) National Oceanic and Atmospheric Administration Sea Grant Program; American Society of Civil Engineers.
(*c*) Professor P. L. Monkmeyer.
(*d*) Theoretical and experimental; applied research; Ph.D. and Master's theses.
(*e*) This study deals with the development of an electronic model of water waves as they enter a harbor and are reflected within it. The purpose of the model is to provide a means to predict wave heights throughout a proposed harbor or modification of an existing harbor. The electronic model, which simulates the Helmholtz equation, is programmed on a hybrid computer.
(*h*) **An Electronic Model of Harbor Waves,** M. M. Sternfeld, L. J. Pratt, P. L. Monkmeyer, *Verification of Mathematical and Physical Models in Hydraulic Engineering, Proc. 26th Ann. Hydraulics Div Specialty Conf.*, Univ. of Maryland, ASCE, pp. 574-582, 1978.

168-11224-820-65

A STUDY OF GROUNDWATER DRAWDOWNS IN DANE COUNTY, WISCONSIN

(*b*) City of Madison, Wisconsin.
(*c*) Professor P. L. Monkmeyer.
(*d*) Computer model and field data; applied research; Master's thesis.
(*e*) A computer model which predicts drawdowns due to pumping in Dane County was recently developed by the U.S. Geological Survey. The purpose of the present project is: to document this model; to add such features as may give it versatility; to apply the model to various pumping schemes, proposed and actual; and to explore the sensitivity of the model to various input parameters.

168-11225-430-54

HYDRODYNAMIC UPLIFT AND OTHER WAVE-INDUCED SEEPAGE EFFECTS ON OFFSHORE STRUCTURES

(*b*) National Science Foundation.
(*c*) Professor P. L. Monkmeyer.
(*d*) Theoretical and experimental; applied research; Ph.D. and Master's theses.
(*e*) In this project a systematic analytical study of the seepage flow field under and around such basic offshore structures as buried pipelines, cylindrical tanks and impervious breakwaters is under way. Darcy's Law and potential theory are being used, to determine pressures, and these in turn are integrated over the structure surface to obtain the hydrodynamics (uplift) force on the structure. The analytic solutions will be verified by an experimental program.
(*g*) For a single, vertical, circular cylinder resting on a seabed of sand of infinite thickness, a theory based on potential flow has been developed to describe seepage pressure, uplift force and overturning moment. Normalized force and moment are presented as a function of "ka" where "a" is the cylinder radius and "k" is the wave number. Pressure distributions generated by a computer program are in good agreement with laboratory experiments.

168-11226-410-36

MONITORING AND EVALUATION OF ASHLAND COUNTY SHORE PROTECTION DEMONSTRATION

(*b*) U.S. Environmental Protection Agency, Red Clay Project.
(*c*) Professor P. L. Monkmeyer.
(*d*) Field study; applied research and monitoring; M.S. thesis.
(*e*) A program has been developed to monitor new shore protection procedures at Madigan Beach and Madeline Island, in Ashland County, Wisconsin on Lake Superior. For two years, prior to the recent installation of Longard tubes at Madigan Beach and a rock revetment at Madeline Island, baseline data has been obtained and analyzed. The data collection and analysis program has included determination of near-shore bathymetry, beach and near-shore sediment sampling, aerial photography to establish bluff recession rates, a wave climate study, and a review of the proposed shore protection plans. With the installation of the shore protection works in 1977, the actual monitoring of the effectivenss of these protection measures was initiated in the summer of 1978.
(*f*) Completed.
(*h*) **Shore Protection Demonstration Project on Lake Superior,** J. A. Shands, P. L. Monkmeyer, T. B. Edil, *Proc. Coastal Zone 78 Conf.*, San Francisco, Calif., sponsored by ASCE, pp. 1954-1972, 1978.
Demonstration of Shoreline Protection on Lake Superior, T. Edil, P. L. Monkmeyer, *Voluntary and Regulatory Approaches For Non-Point Source Pollution Control*, Great Lakes Natl. Program Office, U.S. Environmental Protection Agency, Chicago, Ill., pp. 134-157, 1978.
Evaluation of Shore Protection Demonstrations at Madigan Beach and Madeline Island, Wisconsin, T. B. Edil, P. L. Monkmeyer, N. M. Becker, J. A. Shands, P. R. Wolf, *Final Red Clay Project Report*, Environmental Protection Agency, Superior, Wisc., 1978.

168-11227-810-87

ESTIMATION OF SURFACE DEPRESSION STORAGE

(*b*) Government of Assam, India.
(*c*) Professor P. L. Monkmeyer.
(*d*) Theoretical and field measurements; applied research; Master's thesis.
(*e*) For a particular rainfall event, a portion of the rain can be expected to collect in surface depressions on the land. In this study a procedure is developed to estimate the volume of the surface depressions of a given plot of land. The procedure requires no field measurements, but rather relies on photographs taken from a point directly above the land area of interest. The photographs are analyzed on a stereoplotter to identify the relief, and the surface roughness is described mathematically with the aid of Fourier analysis. The results may then be used to compute the available surface depression storage and to aid in the prediction of the onset of runoff.
(*f*) Completed.

168-11228-870-36

SEEPAGE CHARACTERISTICS OF A SUBSURFACE WASTE DISPOSAL SYSTEM

(*b*) U.S. Environmental Protection Agency and State of Wisconsin.
(*c*) Professor P. L. Monkmeyer.
(*d*) Theoretical and laboratory experimental; applied research; Master's thesis.
(*e*) In this study the seepage characteristics of a small-scale, on-site liquid-waste disposal system are examined. The artificial groundwater mound forming below a liquid-waste

disposal trench has been analyzed both mathematically and experimentally. Predictions of the shape of the mound and the conditions required to provide adequate aeration have been determined for steady and unsteady release of the liquid waste. A design procedure for choosing the spacing of drainage ditches or tiles has also been developed.

(*f*) Completed.

168-11229-810-00

ESTIMATING WITHIN-YEAR STORAGE REQUIREMENTS FOR UNGAGED DRAINAGE BASINS

(*c*) Dr. Kenneth W. Potter, Asst. Professor.
(*d*) Basic research.
(*e*) This project deals with the problem of estimating within-year storage-yield requirements for ungaged drainage basins. One approach will consist of developing relationships between storage-yield curves and selected climatological, physiographic, and geomorphic variables. The second approach will be based on developing stochastic models of weekly streamflow during the critical period of each year. The parameters of these models will be then related to selected basin variables.

UNIVERSITY OF WISCONSIN-MADISON, Department of Geology and Geophysics, Madison, Wis. 53706. Mary P. Anderson, Asst. Professor.

169-09870-820-33

GROUNDWATER-LAKE INTERACTION

(*b*) Office of Water Research and Technology, U.S. Dept. of the Interior.
(*d*) Field and theoretical, applied; M.S. thesis.
(*e*) Investigate the importance of groundwater in the water budget of seepage lakes. A representative lake in northwest Wisconsin has been instrumented. Field data will provide input to a model of the groundwater flow system in the vicinity of the lake.
(*f*) Completed.
(*g*) It was demonstrated by means of field studies and computer simulations that fluctuations in water level in a seepage lake in northwestern Wisconsin were caused by fluctuations in precipitation rather than by changes in the groundwater flow system.
(*h*) **Hydrogeology and Computer Model of the Bass Lake Area, St. Croix County, Wisconsin,** M. B. Rinaldo-Lee, *M.S. Thesis*, Univ. of Wisconsin-Madison, Dept. of Geology and Geophysics, 99 p. (Will also be published as a report by the Water Resources Center, University of Wisconsin, Madison, Wisc.)

169-09871-820-36

HEAT TRANSPORT IN GROUNDWATER

(*b*) EPA.
(*d*) Field and theoretical; applied and development; Ph.D. thesis.
(*e*) Seepage of heated water from a cooling lake and movement of the heat through the groundwater system are being monitored at a site in south central Wisconsin. Field data will provide input for a mathematical model.
(*f*) Completed.
(*g*) The zone of thermally altered groundwater is confined to a relatively small area hydraulically downgradient from the cooling lake. Results from a predictive simulation suggest that when a second 500mw generating unit begins operation in 1978, groundwater temperatures will increase less than 5 °C at distances greater than 15 m from the cooling lake.
(*h*) **Impact of a Power Plant on the Groundwater System of a Wetland,** C. B. Andrews, M. P. Anderson, *Ground Water* **16**, 2, 105-111, 1978.

Thermal Alteration of Groundwater Caused by Seepage from a Cooling Lake, C. B. Andrews, M. P. Anderson, *Water Resources Research* **15**, 1979 (in press).

The Impact of the Use of Heat Pumps on Groundwater Temperatures, C. B. Andrews, *Ground Water* **16**, 6, pp. 437-443, 1978.

The Simulation of Groundwater Temperatures in Shallow Aquifers, C. B. Andrews, *Ph.D. Thesis*, 1978, Univ. of Wisconsin-Madison, Dept. of Geology and Geophysics.

Impacts of Coal-Fired Power Plants on Local Groundwater Systems–Wisconsin Power Plant Impact Study, C. B. Andrews, M. P. Anderson, *Report to EPA*, in review.

169-09872-820-36

GROUNDWATER-SURFACE WATER RELATIONSHIPS IN THE MENOMONEE RIVER BASIN

(*b*) EPA in cooperation with the International Joint Commission.
(*d*) Field, applied; M.S. thesis.
(*e*) Groundwater conditions adjacent to the Menomonee River in southeast Wisconsin are being studied with regard to groundwater flow and water quality. Purpose is to assess the nature and amount of pollutants transported to the Menomonee River by groundwater.
(*f*) Completed.
(*g*) The major contaminants present in the groundwater are chloride, sulfate, ammonium and bacteria. The amount of pollutants discharged to surface water by groundwater systems is small relative to the amount contributed by surface runoff.
(*h*) **Effects of Urbanization on Groundwater Quality–A Case Study,** C. E. Eisen, M. P. Anderson, *Ground Water*, submitted Mar. 1979 (in review).

Final Report of the Menomonee River Pilot Watershed Project, M. P. Anderson, C. E. Eisen, R. N. Hoffer, *Volume 5–Groundwater Hydrology*, Report to EPA, in press.

169-11230-820-54

MATHEMATICAL MODELS OF GROUNDWATER–SURFACE WATER INTERACTION

(*b*) NSF.
(*c*) M. P. Anderson.
(*d*) Theoretical investigation–applied research; M.S. thesis.
(*e*) Mathematical models are applied to study groundwater flow systems in the vicinity of four lakes and two streams in Wisconsin for which field data are available. Purpose is to investigate anomalies observed in the field.

169-11231-820-60

EFFECTS OF URBANIZATION ON GROUNDWATER QUALITY

(*b*) Wisconsin State Geological and Natural History Survey.
(*c*) M. P. Anderson.
(*d*) Field investigation; applied research; M.S. thesis.
(*e*) A watershed in the Milwaukee area has been instrumented with 35 observation wells. Groundwater samples are collected six times per year in order to determine the effects of land use on water quality.
(*g*) Sulfate, chloride and bacteria are the major products of urbanization which affect groundwater quality.

169-11232-820-00

LINKED MODEL OF GROUNDWATER FLOW THROUGH THE SUBSURFACE

(*c*) M. P. Anderson.
(*d*) Theoretical investigation–applied research; M.S. thesis.
(*e*) Several one-dimensional column models of the unsaturated zone are linked to a two-dimensional groundwater flow model. The value of the model will be demonstrated by application to several field situations for which limited data are available. A user's manual will be prepared. Model is intended primarily for use by regulatory agencies and consulting firms.

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UNIVERSITY OF WISCONSIN-MADISON, Marine Studies Center, 1225 W. Dayton Street, Madison, Wis. 53706.

171-10029-440-54

STUDIES OF THE KEWEENAW CURRENT IN LAKE SUPERIOR

(*b*) National Science Foundation.
(*c*) Professor T. Green.
(*d*) Field work; basic research; Masters, Doctoral theses.
(*e*) The strong Keweenaw current along the south shore of Lake Superior has been measured using airborne thermal scanning and photogrammetry, hydrography, and moored current meters. Particular attention is now being paid to flow visualization, thermal fronts associated with the current, and upwelling.
(*f*) Data analysis ongoing; follow-up experiments now being planned.
(*g*) See (h).
(*h*) **The Spatial Variability of Coastal Surface Water Temperature During Upwelling,** Scarpace and Green, *J. Physical Oceanography*, (in press).
A Thermal Scanning Study of Coastal Upwelling on the Great Lakes, Scarpace, Green, and Madding, *J. Remote Sensing of the Environment* (in press).

171-10032-870-33

HIGH-FREQUENCY TEMPERATURE FLUCTUATIONS IN A THERMAL PLUME

(*b*) OWRT, Sea Grant.
(*c*) Professor T. Green.
(*d*) Field work; basic research; Masters thesis.
(*e*) Temperature fluctuations have been measured at seven points in the vertical in a power-plant thermal plume. The results are being interpreted in terms of boundary-layer entrainment mechanisms.
(*f*) Nearly completed.

171-10033-440-44

CURRENT MEASUREMENTS IN THE LAKE MICHIGAN COASTAL ZONE

(*b*) OWRT, Sea Grant.
(*c*) Professor T Green.
(*d*) Field work; basic research; Doctoral thesis.
(*e*) Thirteen current meters were moored in the coastal zone of south-eastern Lake Michigan in the spring and summer of 1976. The data will be processed to measure coherence and phase propagation along the shore.
(*f*) Nearly completed.

171-10034-330-10

FLOW IN THE KEWEENAW WATERWAY, IN LAKE SUPERIOR

(*b*) OWRT, Sea Grant.
(*c*) Professor T. Green.
(*d*) Field work, basic research; Masters thesis.
(*e*) Flow in the Keweenaw Waterway is related to forcing by runoff, by Lake Superior water-level variations, and by atmospheric pressure variations.
(*f*) Nearly completed.

171-11233-700-20

THERMAL SCANNER DESIGN AND USE

(*b*) Office of Naval Research.
(*c*) Professors F. Scarpace and T. Green.
(*d*) Field work, basic research.
(*e*) Thermal scanners are being designed (and existing ones modified) for use aboard a Navy P3 aircraft, in studying oceanic thermal fronts.

171-11234-860-44

REMOTE SENSING OF LAND COVER TO DETERMINE IMPACT OF LAND DEVELOPMENT ON WATER QUALITY

(*b*) NOAA
(*c*) Professor F. Scarpace.
(*d*) Experimental; applied research; Doctoral.
(*e*) Land cover information is being extracted from digitized high altitude imagery and Landsat imagery for use in a sediment run-off model in urban and rural areas of the Green Bay watershed.

171-11235-420-44

LONG WAVE INTERACTIONS

(*b*) NOAA (Sea Grant).
(*c*) Professor T. Green.
(*d*) Experimental, theoretical; basic research; Doctoral thesis.
(*e*) The interaction of long, standing waves is studied experimentally, and theoretically with a two-time-scale perturbation.
(*f*) Completed.
(*h*) **Nonlinear Interaction of Long, Standing Waves,** S. W. Kang, *Ph.D. Dissertation*.

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UNIVERSITY OF WISCONSIN-MADISON, Department of Mathematics, Madison, Wis. 53706. Professor Joshua Chover, Department Chairman.

172-08400-420-54

WATER WAVES IN LAKES AND OCEANS

(*b*) National Science Foundation.
(*c*) Professors R. E. Meyer and M. C. Shen.
(*d*) Theoretical; basic and applied research.
(*e*) Physical oceanography research.
(*h*) **Resonant Refraction by Round Islands,** R. E. Meyer, *Proc. 15th Intl. Conf. Coastal Engrg., ASCE*, Chapt. 50, pp. 866-879, 1976.
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WOODS HOLE OCEANOGRAPHIC INSTITUTION, Woods Hole, Mass. 02543. Dr. John H. Steele, Director.

173-07786-450-20

DYNAMIC PROCESSES IN THE DEEP SEA

(*b*) Office of Naval Research; National Science Foundation.
(*c*) Dr. W. J. Schmitz, Jr., and Dr. N. P. Fofonoff.
(*d*) Field investigations.
(*e*) Time series observations in the deep ocean support theoretical work on the nature of dynamic processes in the sea. Several experiments are usually in progress simultaneously.
(*g*) Several recent experiments have yielded the following information: (1) data from an array of current meters in the deep Gulf Stream recirculation region suggests that this recirculation is driven by the oceanic eddy field; (2) Gulf Stream rings have been identified as possible sources for enhanced fine-structure activity near Bermuda through the generation of internal waves by eddy interaction with the island slope and subsequent mixing by the internal wave field; (3) a new current was found near 4,000 in depth along the western foot of the Bermuda Rise.

(*h*) **Some Evidence for Boundary Mixing in the Deep Ocean,** L. Armi, *J. Geophys. Res.* **83,** 1971-1979, 1978.
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173-09224-440-44

COASTAL CIRCULATION IN THE GREAT LAKES

(*b*) NOAA, Great Lakes Environmental Research Laboratory.
(*c*) Dr. Gabriel T. Csanady.
(*d*) Analysis of field data, theoretical work.
(*e*) Data collected during the International Field Year on the Great Lakes are analyzed and interpreted in terms of the concepts of fluid mechanics.
(*g*) Concentrated bands of relatively fast currents are produced by storms near the shore of large lakes within what is now known as the "coastal boundary layer." The physical properties of the coastal currents depend not only on the size and shape of the lake basin, but also significantly on the density distribution of the water and the rotation of the earth.
(*h*) **Mean Circulation in Shallow Seas,** G. T. Csanady, *J. Geophys. Res.* **81,** 30, pp. 5389-5399, 1976.
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173-09225-450-52

COASTAL BOUNDARY LAYER TRANSECT

(*b*) Department of Energy.
(*c*) Dr. Gabriel T. Csanady.
(*d*) Theoretical and field investigations.
(*e*) Current, temperature and salinity measurements in the coastal zone (0-12 km from shore) south of Long Island are used to elucidate flow structure in the coastal boundary layer.
(*g*) The transient and the long-term circulation over continental shelves is determined by impulses received from winds and tides as well as by the density distribution of the water. An important part of the transient shelf-wide flow pattern is the coastal boundary layer where storms produce concentrated bands of currents. Time-averaged flow is, by contrast, controlled by density variations consequent upon fresh water runoff near shore and by the pressure field of large oceanic gyres.
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173-09226-450-20

OCEANIC VARIABILITY AND DYNAMICS

(*b*) Office of Naval Research; National Science Foundation.
(*c*) Dr. Thomas B. Sanford.
(*d*) Theoretical and field investigations.
(*e*) Most of the effort concentrates on the measurement and interpretation of motionally induced electric fields arising with water moving through the geomagnetic field. Theoretical studies and field observations are combined to define the spatial and temporal structure of flow in shallow channels and in the deep ocean.
(*g*) A better understanding of the physics of induction in broad shallow channels has been achieved. Thus understanding allows, under certain circumstances, the transport of a stream to be electrically monitored. In the deep ocean measurements of electric current profiles have revealed new data on the vertical structure of horizontal

currents. Much of the depth-dependent variability is contributed by inertial currents.

(*h*) **A Velocity Profiler Based on Acoustic Doppler Principles,** R. G. Drever, T. B. Sanford, *Woods Hole Oceanographic Inst. Tech. Rept. WHOI 76-96*, 39 pp., 1976.

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Performance of An Absolute Velocity Profiler Based on Acoustic Doppler and Electromagnetic Principles, J. H. Dunlap, T. B. Sanford, R. G. Drever, *Woods Hole Oceanographic Inst. Tech. Rept. WHOI 78-28*, pp. 60, 1978.

WORCESTER POLYTECHNIC INSTITUTE, Alden Research Laboratories, 30 Shrewsbury Street, Holden, Mass. 01520. George E. Hecker, Director, Research Laboratories.

174-11236-850-73

MODEL STUDIES OF THE PROPOSED VERNON DAM FISH PASSAGE FACILITY

(*b*) New England Power Company.
(*d*) Experimental design.
(*e*) Hydraulic models were constructed to investigate the operating characteristics of the fishway right entrance weir makeup flow diffusion chamber and the fishway exit control section including the fish exit. The two models were each constructed to a scale of 1 to 10. The object of the studies was to provide a fishway which would maximize fish passage while minimizing construction and operating costs. The exit control section was evaluated by measuring water required for operation, water surface drop between pools, velocities, flow patterns, and power dissipation. The right entrance weir makeup flow diffusion chamber was designed to produce a uniform velocity over the entire diffuser exit area.
(*f*) Study to be completed, Spring 1979.

174-11237-340-73

DISCHARGE STRUCTURE TESTING FOR A PUMPED STORAGE POWER PLANT, BAD CREEK PROJECT

(*b*) Duke Power Company, Charlotte, North Carolina.
(*d*) Experimental design.
(*e*) A 1 to 56 scale model of a section of the lower reservoir of the discharge structure for a proposed 1000 MW pumped storage power plant was constructed to evaluate plant operation. The velocity distribution, head loss, and vortexing tendencies of the discharge structure were evaluated and modifications made to improve performance. Effects on flow patterns and erosion potential were investigated in the lower reservoir.
(*f*) Study to be completed spring 1979.

174-11238-340-75

HYDRAULIC MODEL INVESTIGATION OF THE EXISTING DILUTION WATER PUMP INTAKE, NORTHPORT POWER STATION

(*b*) Ebasco Services, Inc., Long Island Lighting Company.
(*d*) Experimental design.
(*e*) A 1 to 9 scale model of the dilution pump intake was constructed to study flow patterns within the pumpwell to determine if operational difficulties such as shroud damage, cavitation, and rubbing of the impeller were caused by flow patterns approaching the pump.
(*f*) Completed.
(*g*) Undesirable flow patterns and surface vortices were present in the model throughout the operating range. A curtain wall upstream of the pump, a splitter wall under the pump bell, and the streamlining of existing structural members of the pumpwell eliminated all surface velocities and undesirable flow patterns in the model.
(*h*) **Hydraulic Model Investigation of the Existing Dilution Water Pump Intake, Northport Power Station,** D. K. White, J. Larsen, *ARL Rept. No. 22-79/M71F*, Feb. 1979.

174-11239-210-65

PROBABLE CAUSE INVESTIGATION OF THE FAILURE OF A FORCE MAIN

(*b*) Town of South Windsor, Connecticut.
(*d*) Field investigation, applied research.
(*e*) A 3000 foot, 10-inch diameter polyvinyl chloride pressure pipeline and a pumping station were put into service in 1973 to lift sewage into a gravity main. After experiencing approximately 60 breaks, the PVC line was replaced with ductile iron pipe in 1976. The investigation evaluated plans and specifications, pipe specimens, pipe installation, construction inspection records, and pressure fluctuation during operation.
(*f*) Completed.
(*g*) The failure of the 10-inch PVC force main was the result of several contributing factors. (1) Plans and specifications did not adequately specify the system check valves nor had the specified PVC pipe been proven for use in a surging pressure application. (2) The quality of workmanship in placing the pipe was poor. (3) Acceptance pressure testing was not according to specifications and sections of main were not tested. (4) Pressure transients generated by pump shutdown and subsequent valve closures contributed to the fatigue failure of the PVC pipe.
(*h*) **Probable Cause Investigation of the Failure of a Force Main in the Town of South Windsor, Connecticut,** D. K. White, M. Padmanabhan, J. Larsen, *ARL Rept. No. 11078/M362F*, Feb. 1978.

174-11240-870-75

WASTEWATER DIVERSION STRUCTURE, 69TH STREET TREATMENT PLANT

(*b*) Lockwood, Andrews & Newman, Inc., Houston, Texas.
(*d*) Experimental for design.
(*e*) A 1/9 uniform scale model was constructed of a sewage diversion structure designed to divert influent into three outfall lines. Structure head loss, gate ratings, and mixing of influent within the structure were measured.
(*f*) Completed.
(*g*) Diversion structure head losses were measured to determine the effect on the hydraulic gradeline in the upstream gravity mains. The coefficient of discharge of each of the three gates was measured to enable the computation of flow in the prototype outfall lines as a function of diversion structure water level and gate position. Dye dilution tracer techniques were utilized to determine the degree of mixing of the influent within the diversion structure.
(*h*) **Wastewater Diversion Structure, 69th Street Treatment Plant,** D. K. White, J. Larsen, *ARL Rept. No. 146-77/M342AF*, Oct. 1977.

174-11241-870-75

INVESTIGATION OF FLOW PATTERNS IN A MODEL SPIRAL-FLOW TYPE GRIT CHAMBER

(*b*) Lockwood, Andrews & Newnam, Inc., Houston, Texas.
(*d*) Experimental for design.
(*e*) A 1/15 uniform scale model was constructed of a 50 mgd spiral-flow aerated type grit chamber. The study investigated flow patterns, retention time, and grit removal efficiency.
(*f*) Completed.
(*g*) The entrance to the grit chamber was streamlined to eliminate areas of backflow and reduce the maximum velocities. Internal baffles were modified to strengthen the spiral flow pattern and improve grit removal.
(*h*) **Investigation of Flow Patterns in a Model Spiral-Flow Type Grit Chamber,** J. Larsen, D. K. White, N. E. Billings, *ARL Rept. No. 83-78/M342BF*, Sept. 1978.

174-11242-340-73

INTAKE STRUCTURE TESTING FOR A PUMPED STORAGE PLANT

(*b*) Duke Power Company, Charlotte, North Carolina.
(*d*) Experimental design.
(*e*) A 1/58 scale hydraulic model was constructed of the upper reservoir to evaluate the plant intake for potential vortices, vibrations, and head losses during generation. Velocity distributions and head losses in the pumping mode were also investigated.
(*f*) Essentially completed.
(*g*) The original solid roofed radial flow intake had unacceptably strong vortices. The intake was lowered and revised. It was determined that solid roofed or uncovered intakes would perform without vortices when there was sufficient submergence, and relatively low uniform approach and entrance velocities. The uncovered intake had the least cost and, therefore, will be included in the final design. To minimize the potential of vortices, large beams were installed 70 ft over the intake to dissipate swirling motion.

174-11243-340-73

VELOCITIES PRODUCED BY A SMALL HYDROELECTRIC PLANT

(*b*) American Electric Power Service Corporation, Ohio Power.
(*d*) Experimental design.
(*e*) Two hydraulic models of 1/45 scale (powerhouse model) and 1/150 scale (overall model) were constructed to evaluate the flow patterns approaching and leaving a new powerhouse to be constructed at the Racine Locks and Dam on the Ohio River. The primary objective of the powerhouse model was to optimize the flow pattern approaching the turbines by minimizing approach angle and non-uniformity of the velocity distribution. Other objectives included testing for vortices and determining riprap requirements. The overall model evaluated the effect of the proposed powerhouse on flow patterns at the nearby Racine Locks. The Army Corps of Engineers specified that there should be no significant changes.
(*f*) Completed.
(*g*) The powerhouse model indicated that flow approaching the intake would be at an angle of approximately 45° compared to an allowable maximum of 15°. A guide pier reduced the angle. The overall model indicated that the flow pattern produced by the proposed powerhouse in the approach downstream of the dam varied with river flow and the topography in the tailrace. An optimum topography was determined such that at low flows, when the powerhouse affected the patterns at the lock, conditions were essentially unmodified.

174-11244-340-73

CLIFTY CREEK STATION–SEDIMENTATION IN INTAKE FOREBAY

(*b*) Indiana-Kentucky Electric Power Corporation, Piketon, Ohio; American Electric Power Service Corporation, New York, N.Y.
(*d*) Experimental, for design.
(*e*) A 1/30 scale model of the intake forebay and adjacent river area was constructed for the Clifty Creek Station in Madison, Indiana. The model was constructed using concrete on packed sand with elevated wooden templates. Intake and discharge structures were constructed from plywood. The model was used to determine the mechanisms currently leading to sedimentation in the prototype structure. The intake forebay design was then revised in an attempt to alleviate conditions leading to sedimentation for any ambient river elevation.
(*f*) Study complete, report in progress.
(*g*) No free surface flow design was found which maintained correct flow patterns and velocities for all river stages. The final solution could be timed to give good results for any given river stage.

174-11245-340-73

JAMESPORT NUCLEAR POWER STATION–DIFFUSER MODEL

(*b*) Long Island Lighting Company, Hicksville, New York.
(*d*) Experimental, for design.
(*e*) A 1/100 scale model of a portion of the coastline near Jamesport, New York on Long Island was constructed. A diffuser of varying nozzle orientation and length was tested in order to minimize the overall length. The model was 130 ft by 85 ft in extent, and was constructed using fiberglass coated, 1/4 inch plywood on raised templates. Surface and vertical structure of the plume were measured using 480 thermocouple probes in transient cross-flow conditions.
(*f*) Tests in progress.

174-11246-340-73

BRUNNER ISLAND STATION–DISCHARGE CANAL STUDY

(*b*) Pennsylvania Power & Light, Allentown, Pa.
(*d*) Experimental, for design.
(*e*) A 1/15 scale model of the discharge canal of the Brunner Island Steam Electric Station in York Haven, Pennsylvania, was constructed in order to investigate various remedial schemes for conducting full mixing of two co-flowing discharge streams. The model was constructed using fiberglass or plywood. Fine topographic details were modeled in concrete. Temperatures in the canal were measured using 130 thermocouple probes.
(*f*) Tests in progress.

174-11247-340-73

CAMPBELL ELECTRIC GENERATING STATION–SUBMERGED INTAKE STUDY

(*b*) Commonwealth Associates, Inc., Jackson, Michigan; Consumers Power Company, Jackson, Michigan.
(*d*) Experimental, for design.
(*e*) A model study for offshore submerged intakes for the J. H. Campbell plant on Lake Michigan was conducted. A 1/65 undistorted model from previously reported study was used to optimize the placement of from 1 to 3 submerged intakes directly offshore of a staged diffuser discharge. The critical quantity in the study was the recirculation temperature rise in the intakes due to the discharge plume. Temperatures in the model were measured using 370 thermocouple probes. The model was constructed using fiberglass covered, 1/4 inch plywood on elevated templates.
(*f*) Study complete, report on file.
(*g*) It was found that locating the intakes 3500 ft offshore, or 1500 ft offshore of the diffuser, produced adequate results in terms of minimizing intake recirculation temperatures.

The intakes were located in 36 ft of water, while the depth at the diffuser varied between 20 and 28 ft.

(*h*) **Minimization of Recirculation in Submerged Intakes Located Offshore of a Diffuser Discharge,** J. T. Kirby, Jr., D. N. Brocard, *ARL Rept. No. 35-78/M182CF*.

174-11248-850-70

DEVELOPMENT OF FISH PROTECTIVE SYSTEMS AT POWER PLANT INTAKES

(*b*) Empire State Electric Energy Research Corporation, Schenectady, New York.
(*d*) Experimental for development.
(*e*) Previous studies have shown that juvenile fish can be separated from the circulating water of electric generating stations. An angled screen or a behavioral barrier system may be used to divert fish from the intake flow to a bypass and return them to their natural habitat. The current studies are designed to evaluate the efficiency of the systems for various species and over a wide range of water temperatures. Preliminary evaluations of fine mesh angled screens for the diversion of larvae were conducted. A peripheral jet pump and a centrifugal fish pump were evaluated for use in a fish transportation system. Further studies of the fine mesh screens and pumps are scheduled with larvae stages of different species for the 1979-80 seasons. In addition, laboratory impingement survival studies will be conducted.

174-11249-340-60

PRATTSVILLE PUMPED STORAGE MODEL

(*b*) Power Authroity of the State of New York; Charles T. Main International.
(*d*) Experimental for evaluation.
(*e*) Hydrothermal model study of lower reservoir of pumped storage project to determine the effect of the pumped storage operations on natural temperature stratification and reservoir turbidity. Several dredging configurations were also considered to minimize the induced flow velocities.
(*f*) Completed.
(*g*) The pumped storage operation tends to destroy the natural stratification by turbulent jet mixing during generating modes and by mixing, in the upper reservoir, of waters of different temperatures withdrawn during pumping modes. Induced flow velocities can be reduced by selective dredging.
(*h*) **Effect of Pumped Storage Operation on Reservoir Temperature and Turbidity–Prattsville Pumped Storage Project,** D. N. Brocard, R. G. Nyquist, *ARL Rept. No. 134-79*, Sept. 1978.

174-11250-340-73

MERCER HEATED DISCHARGE

(*b*) Public Service Electric and Gas Company of New Jersey.
(*d*) Analytical for evaluation.
(*e*) Mathematical model of thermal plume produced by surface discharge in the Delaware River of waste heat from Mercer Generating Station. The modeling approach used in this study included a transient one-dimensional model to account for the effects of tides on background temperature rises and a three-dimensional nearfield model for the prediction of temperatures in the plume. This model, of the integral type, included the treatment of the jet impingement on the shore opposite the discharge.
(*f*) Completed.
(*g*) Results were presented in terms of surface and subsurface temperature rise isotherms for use by power company to establish compliance with existing environmental regulations.
(*h*) **Mathematical Model of Heated Surface Discharge in Confined Tidal Estuary, Mercer Generating Station,** D. N. Brocard, S. K. Hsu, *ARL Rept. No. 68-78*, Mar. 1978.

174-11251-340-73

PALISADES DIFFUSER

(*b*) Consumers Power company.
(*d*) Mathematical modeling.
(*e*) Development and application of mathematical model for "staged" diffuser in shallow water. Staged diffusers are characterized by a small angle between discharge nozzles and diffuser axis and produce a net momentum in the offshore direction. The model used is of the integral type in that it considers integrated equations in a section of the plume. The diffuser is simulated as a continuous source of heat and momentum.
(*g*) The model was verified with several model study measurements and was applied to design a diffuser for the waste heat discharge from the Palisades nuclear generating station, which is located on Lake Michigan.

174-11252-340-73

NORTH ANNA NUCLEAR STATION–CONTAINMENT RECIRCULATION SUMP MODEL STUDY

(*b*) Virginia Electric and Power company, Richmond, Virginia.
(*d*) Experimental.
(*e*) To establish that the pumps in the Emergency Core Cooling System which draw water from the containment sump would operate satisfactorily without being affected by any adverse flow conditions such as air-entraining vortices existing in the sump. A hydraulic model to the geometric scale of 1:3 was tested at the various operating conditions of flow combinations, submergence and near and farfield obstructions to the approach flow.
(*f*) Tests completed.
(*g*) For certain test conditions, strong vortices entraining air were present for the original design. Vortex suppressing devices were installed and the modified sump performed satisfactorily.
(*h*) **Hydraulic Model Studies of the Reactor Containment Sump–North Anna Nuclear Power Station, Unit 1,** M. Padmanabhan, *ARL Rept. No. 123-77/M250CF*.

174-11253-340-73

McGUIRE NUCLEAR POWER STATION–CONTAINMENT RECIRCULATION SUMP MODEL STUDY

(*b*) Duke Power Company, Charlotte, North Carolina.
(*d*) Experimental.
(*e*) To establish that the pumps in the Emergency Core Cooling system which draw water from the containment sump would operate satisfactorily without being affected by any adverse flow conditions in the sump such as air-entrainment due to breakflow jet impingement and air drawing vortices. A hydraulic model to the geometric scale of 1:3 was tested at the various operating conditions.
(*f*) Tests completed.
(*g*) Because of the sump location near the break flow jet impingement area, high air entrainment was noted for the original design due to high velocity jets. Sump was redesigned locating outside the region of jet impingement and a satisfactory performance was noted. No air-entraining vortices occurred for the revised design.
(*h*) **Assessment of Flow Characteristics Within a Reactor Containment Recirculation Sump Using a Scale Model,** M. Padmanabhan, *ARL Rept. No. 29-78/M208JF*, May 1978.

174-11254-340-73

DONALD C. COOK NUCLEAR POWER STATION–CONTAINMENT RECIRCULATION SUMP MODEL STUDY

(*b*) American Electric Power Service Corporation, New York.
(*d*) Experimental.
(*e*) To establish that the pumps in the Emergency Core Cooling system which draw water from the containment sump would operate satisfactorily without being affected by any adverse flow conditions in the sump such as air-entrainment due to breakflow jet impingement and air drawing vortices. A hydraulic model to the geometric scale of 1:2.5 is being tested.

(*f*) Tests in progress.
(*g*) Tests on vortex identification indicated no air entraining vortices. Minor changes suggested to reduce swirl intensities and air entrapment on top covers. Tests are being conducted to study jet impingement problems.

174-11255-340-73

SEABROOK NUCLEAR POWER STATION–CONTAINMENT RECIRCULATION SUMP MODEL STUDY

(*b*) Yankee Atomic Electric Company, Public Service Company of New Hampshire.
(*d*) Experimental.
(*e*) To establish that the pumps in the Emergency Core Cooling System which draw water from the containment sump would operate satisfactorily without being affected by any adverse flow conditions such as air-entraining vortices existing in the sump. A hydraulic model to the geometric scale of 1:4 is being tested at various operating conditions of flow combinations, submergence and near and farfield obstructions to the approach flow.
(*f*) Tests in progress.
(*g*) Preliminary tests indicated that the sump would perform satisfactorily.

174-11256-340-73

HOPE CREEK NUCLEAR GENERATING STATION–CONDENSER WATERBOX MODEL

(*b*) Public Service Electric and Gas Company, New Jersey; Bechtel Power Corporation; Southwestern Engineering Company.
(*d*) Experimental.
(*e*) A high content of abrasive silt in the circulating water increases the potential for rapid condenser tube erosion. If the inlet waterbox design produces regions of high velocity within the waterbox, this could result in accelerated erosion, as well as decreased condenser efficiencies and increased loss. A hydraulic model, constructed to a geometric scale ratio of 1:7.8, was used to determine flow patterns, velocity distribution, and losses within an inlet waterbox. The potential for erosive wear was evaluated on the basis of particle impingement angles and velocities. Using this criterion, the original design and a variety of revisions were investigated in the model.
(*f*) Tests completed.
(*g*) No major revisions in the design were found necessary.
(*h*) **Velocity Distributions, Turbulence Intensities, and Head Losses in a Two-Pass Condenser Model,** P. A. March, *ARL Rept. No. 9-78/M358AF*, Apr. 1978.

174-11257-340-73

McGUIRE NUCLEAR POWER STATION–COMBINED BEND IN SUCTION PIPING

(*b*) Duke Power Company, Charlotte, North Carolina.
(*d*) Experimental.
(*e*) A 1:2 model of the combined bend suction pipe layout was tested to study the flow pattern at the outlet and to derive modifications to improve it to be uniform enough for a satisfactory performance of the double suction centrifugal type service water pump.
(*f*) Tests completed.
(*g*) Tests indicated the original layout produced a flow imbalance of about 8 percent at the outlet. A mitered vaned elbow with special vane arrangement derived from tests was used to replace the last short radius curved bend and the flow imbalance was reduced to about 1 percent.
(*h*) **An Investigation of Flow Distribution and Swirl Due to a Combined Bend,** M. Padmanabhan, *ARL Rept. No. 12-79/M208MF*, Dec. 1978.

174-11258-340-73

SEABROOK NUCLEAR POWER STATION–TRANSIENT ANALYSIS OF COOLING WATER SYSTEM

(*b*) Yankee Atomic Electric Company; Public Service Company of New Hampshire.
(*d*) Analytical.
(*e*) A computer model of the cooling water system has been formulated to study the transient water levels due to various operational procedures such as pump start-up, pump shut-down, power failure and back-flush heat treatment in different structures of the cooling water system. A separate waterhammer analysis to study transient pressures in the condenser waterbox and portions of pipes near it is being undertaken. The study would also provide operational data so as to minimize the effects due to transients.
(*f*) Study in progress.

PROJECT REPORTS FROM U.S. GOVERNMENT LABORATORIES

U.S. DEPARTMENT OF AGRICULTURE, SCIENCE AND EDUCATION ADMINISTRATION, AGRICULTURAL RESEARCH

NORTH CENTRAL REGION, 2000 West Pioneer Parkway, Peoria, Ill. 61615. E. R. Glover, Regional Administrator.

300-01723-350-00

HYDRAULICS OF WATER CONTROL STRUCTURES AND CHANNELS

See St. Anthony Falls Hydraulic Lab. Project Nos. 00111, 01168, 07677, and 10592.

(*b*) Cooperative with the Minnesota Agric. Expmt. Station; and the St. Anthony Falls Hydraulic Laboratory.

(*c*) Mr. Fred W. Blaisdell, Research Leader, St. Anthony Falls Hydraulic Lab., 3rd Ave. S. E. at Mississippi River, Minneapolis, Minn. 55414.

(*d*) Experimental; applied research for development and design.

(*e*) Research dealing with the design, construction, and testing of structures for conserving and controlling soil and water are carried out. Cooperation with and coordination of the tests at the Stillwater, Oklahoma, Water Conservation Structures Laboratory is maintained. Model tests of the Marsh Creek Dam principal spillway, Contra Costa County, California, have been completed. Present research is a generalized investigation of the scour at cantilevered pipe outlets. The objective is to develop criteria for the design of plunge pool energy dissipators for any pipe size, discharge, and bed material.

(*h*) The following reports are available from the address listed in (c) at no cost:

Hydraulic Model Investigation of a Two-Way Drop Inlet for Floodwater Retarding Structure No. 3, Banklick Creek Watershed, Boone and Kenton Counties, Kentucky, *ARS-NC-63*, 20 pages, Aug. 1978.

Hydraulics of Closed Conduit Spillways, Part XVI: Elbows and Transitions for the Two-Way Drop Inlet, *AAT-NC-1*, 44 pages, Feb. 1979.

Hydraulics of Closed Conduit Spillways, Part XVII: The Two-Way Drop Inlet With a Semicylindrical Bottom, 28 pages, Apr. 1979.

300-04275-830-00

MECHANICS AND CONTROL OF EROSION BY WATER

(*b*) Cooperative with Purdue University Agricultural Expmt. Station.

(*c*) W. C. Moldenhauer, Agronomy Dept., Life Science Bldg., Purdue Univ., Lafayette, Ind. 47907.

(*d*) Experimental, theoretical, and field investigations; basic, applied and developmental research.

(*e*) Field, laboratory, and analytical studies of soil detachment and transport by rainfall and runoff; effects of plant covers, crop residues, tillage methods, and soil treatments on erosion and runoff; hydraulics of eroding runoff and rainfall; and mathematical models of the soil erosion process as a basis for improved methods of erosion prediction and erosion control.

(*g*) A model was developed to estimate both amount and composition of sediment coming from agricultural fields. The model, based on fundamental concepts for detachment, transport, and deposition and readily available parameter values, requires no calibration. The watershed is represented by overland flow, concentrated flow, and impoundment elements. The user can analyze the influence of a broad range of management practices including terraces, waterways, conservation tillage, buffer strips, strip cropping, impoundments and topographic features like concave slopes, field boundaries, and flow concentrations. The model operates cheaply for either single storms or 20 or more years of record. Deposition studies on field plots caused by concave slopes and strips of mulch and sod showed how these features affect amount of deposition and composition of the sediment load. Strips of mulch and sod in heavy covers can remove up to 75 percent of the sediment for strips as narrow as 6 ft. These data are being used to validate deposition relationships for erosion models. A new rainfall simulator having a wide range of controllable intensities and very short delay times between spray applications was developed that is a significant improvement over current rainfall simulators for the study of rainfall pattern on infiltration and erosion on plots as long as 150 ft.

(*h*) **Universal Soil Loss Equation (USLE), Runoff Erosivity Factor, Slope Length Exponent and Slope Steepness Exponent for Individual Storms,** F. Lombardi, *Ph.D. Thesis*, Purdue University, 1979.

Predicting Rainfall Erosion Losses: A Guide to Conservation Planning, W. H. Wischmeier, D. D. Smith. USDA Science and Education Administration, *Agriculture Handbook 537*, pp. 58, 1978.

Control of Nonpoint Water Pollution from Agriculture, M. H. Frere, D. A. Woolhiser, J. H. Caro, B. A. Stewart, W. H. Wischmeier, *J. Soil and Water Conservation 32:260-264*, 1977.

An Erosion Equation Derived from Basic Erosion Principles, G. R. Foster, L. D. Meyer, C. A. Onstad, *Trans. Amer. Soc. of Agric. Engineers 20(4):678-682*, 1977.

A Runoff Erosivity Factor and Variable Slope Length Exponents for Soil Loss Estimates, G. R. Foster, L. D. Meyer, C. A. Onstad, *Trans. Amer. Soc. of Agric. Engineers 20(4):683-687*, 1977.

Measuring the Amounts of Crop Residue Remaining After Tillage, L. L. Sloneker, W. C. Moldenhauer, *J. Soil and Water Conservation 32:231-236*, 1977.

Soil Erosion and Sedimentation by Water–An Overview, G. R. Foster, L. D. Meyer. In: *Proc. Natl. Symp. Soil Erosion and Sedimentation by Water*, Amer. Soc. Agric. Engineers, Chicago, Ill., Dec. 12-13, 1977.

300-09272-810-00

PREDICTING THE WATER BALANCE AND RUNOFF FROM WATERSHEDS IN THE NORTH APPALACHIAN REGION

(*b*) Cooperative with the Ohio Agricultural Research and Development Center, Wooster, Ohio 44691.

(*c*) C. R. Amerman, Acting Location/Research Leader, USDA-SEA-AR, North Appalachian Experimental Watershed, Coshocton, Ohio 43812.

(*d*) Experimental, theoretical, and field investigations; basic and applied research.

(*e*) Watershed and lysimeter studies on water yielded from agricultural lands under different management practices

and modeling of flow components of the hydrologic cycle, particularly infiltration and evapotranspiration.

(*g*) A numerical solution to the unsaturated soil moisture flow equation allows for vertical infiltration and for excess precipitation that flows into noncapillary holes to move internally. The practical applicability of using snowfall measurements obtained from a dual-gage arrangement of an unshielded and a shielded recording gage to compute actual snowfall has been verified, giving value within 5 percent of that reaching the ground at protected wooded sites. Pastures used for winter feeding experienced a 5-6 fold increase in surface runoff over that predicted for no land-use change. Also, surface runoff was 6-18 times greater and yearly peaks 10-18 times greater on the winter feeding areas as compared to summer pastures.

(*h*) **Soil Crusting,** W. M. Edwards, In: *USDA-SEA-AR, Research Progress and Needs–Conservation Tillage, ARS-NC-57*, pages 35-42, Oct. 1977.

Runoff Controlling Hydraulic Properties of Erosion Susceptible Grey-Brown Podzolic Soils in Germany, W. Ehlers, W. M. Edwards, R. R. van der Ploeg, *Proc., Workshop on Assessment of Erosion in USA and Europe*, Univ. of Ghent, Ghent, Belgium, Mar. 1978.

Infiltrometer Using Simulated Rainfall for Infiltrometer Research, W. R. Hamon, In: C. R. Amerman (ed.), *Proc. Infiltration Research Planning Workshop. I. State of the Art Reports, ARM-NC-4*, Apr. 1979.

Hydrology and Chemical Quality of Flow from Small Pastured Watersheds. I. Hydrology, R. W. VanKeuren, J. L. McGuinness, F. W. Chichester, *J. Environmental Quality 8(2)*, 1979.

300-09273-870-00

FIELD DETERMINATION OF NUTRIENTS AND SEDIMENTS FROM NON-POINT SOURCES

(*b*) Cooperative with the Minnesota Agricultural Experiment Station, St. Paul, Minn. 55108.

(*c*) R. A. Young and C. A. Onstad, Agric. Engineers, North Central Soil Conservation Research Center, Morris, Minn. 56267.

(*d*) Experimental, theoretical, and field investigations; basic and applied research.

(*e*) Assess the impact of man on nutrient enrichment of lakes and streams. Develop hydrologic and nutrient budget for agricultural and non-agricultural watersheds. Relate water quality and sediment yield to watershed land use practices. Model agricultural chemical transport.

(*g*) Hydrological, soil, and water quality conditions were monitored and data collected for three years on a forested watershed which was then closed out in the spring of 1977. This data and data from an agricultural watershed are to be used to try and verify an erosion model based on fundamental principles. Soil surveys, farm plans, and animal, cropping, and other land use practices have been determined for an agricultural watershed. Monitoring and data collection is continuing on the watershed. This watershed became operational in 1975, about the start of the 1975-76 drought. There were no runoff events in 1976 because of the severe drought conditions, and in 1977 because the soil profile was being recharged after the drought. The first significant runoff events were in 1978. Thus, at least one more year of monitoring is necessary for a needed minimum of two years of measurements. The fourth and final year of study of the effect of applying different rates of liquid manure to frozen ground in midwinter on soil loss, runoff, and nutrient losses was completed. The runoff plots which were used in the first three years of the study were closed out in 1977. However, four different rates of manure–0, 0.33, 0.67, and 1.0 inches–were applied to four small watersheds, 2 to 4 acres in size for the second successive year. As with all of the preceding years, amounts of runoff and nutrient losses from snowmelt varied inversely with the amount of manure applied. Results from summer rainstorms for 1978 have not yet been analyzed.

(*h*) **Animal Waste Utilization on Crop and Pastureland: A Manual for Evaluating Agronomic and Environmental Aspects,** C. B. Gilberston, et al. Cooperative Manual between EPA and SEA. In print.

Effectiveness of Nonstructural Feedlot Discharge Control Practices, R. A. Young, T. Huntrods, W. Anderson. Unpublished. *Paper No. 78-2572*, ASAE Winter Mtg., Chicago, Ill., Dec. 18-20, 1978.

300-10561-220-00

PREDICTING EROSION AND SEDIMENT YIELDS FROM AGRICULTURAL WATERSHEDS

(*b*) Cooperative with Minnesota Agricultural Experiment Station, St. Paul, Minn. 55108.

(*c*) C. A. Onstad and R. A. Young, Agricultural Engineers, North Central Soil Conservation Research Center, Morris, Minn. 56267.

(*d*) Experimental, theoretical, and field investigations; basic and applied research.

(*e*) Models have been developed to estimate erosion and sediment yield from ungaged agricultural basins. Simulation timeframes range from single storms to average annual amounts. Spatial distribution of sediment sources within the basin are also predicted. Plot experiments, indoor and outdoor, are being conducted to provide quantification of sediment characteristics deemed pertinent for the transport of agricultural chemicals. Data are also being collected from agricultural basins to relate water quality and sediment yield to land use practices.

(*g*) Sediment yield models incorporating hydrologic and hydraulic flow properties have been designed for single storms and annual amounts. Several models that can be applied to relatively large watersheds (greater than 30,000 ha) and that are based on data generally available were developed and tested. The models estimate both average end of slope erosion and basin yield with various management practices being simulated within the segments that comprise the watershed. Soil susceptibility to rilling was examined in terms of some soil characteristics, principally the degree of aggregation of the soil, aggregate stability, organic matter content, and particle size distribution. Highly aggregated soils with relatively water-stable aggregates were less susceptible to interrill erision or erosion by raindrop than more poorly aggregated soils. However, soil low in organic matter was much more susceptible to erosion by runoff and thus, tended to rill more readily. Known amounts of rainfall energy were applied to land having a history of controlled wheel traffic. Field and laboratory measurements were made on soil and sediment samples from the wheel track and nontracked areas to determine basic cause and effect relationships between wheel traffic, soil compaction, and erosion. Root and shoot growth and decay of corn and soybeans from planting time, throughout the growing season, and into the next planting season are being compared to determine the influence of soybeans on soil physical properties that may relate to soil erodibility. Microbial activity is also being closely examined.

(*h*) **Characterization of Rill and Interrill Eroded Soil,** R. A. Young, C. A. Onstad, *Trans. ASAE 29(6):1126-1130*, 1978.

Sediment Yield Modeling for 208 Planning, C. A. Onstad, R. A. Young, M. A. Otterby, R. F. Holt. Chap. 4 of USLE published by ASA, 1978.

Wheel Traffic Considerations in Erosion Research, W. B. Voorhees, R. A. Young, L. Lyles, *Paper No. 78-2083, ASAE Ann. Mtg.*, Logan, Utah, June 1978.

Assessment of Upland Erosion and Sedimentation from Agricultural Nonpoint Sources in Minnesota, M. A. Otterby, C. A. Onstad. Unpublished report. Submitted to Minnesota Soil and Water Conservation Board and Minnesota Pollution Control Agency, 1978.

300-11392-810-34

HYDROLOGY AND WATER QUALITY OF WATERSHEDS SUBJECTED TO SURFACE MINING

(*b*) U.S. Department of Interior, Bureau of Mines.

(*c*) W. R. Hamon and J. V. Bonta, Research Hydraulic Engineers, USDA-SEA-AR, North Appalachian Experimental Watershed, Coshocton, Ohio 43812.

(*d*) Experimental, theoretical and field investigations; basic and applied research.

(*e*) Investigation of the hydrologic and water quality conditions occurring before, during, and after surface mining.

(*g*) Data were collected on soils, vegetation, geology, runoff and water quality from a control watershed and from three other watersheds, two of which were mined in 1977, and reclaimed during 1978. Water quality parameters for unmined conditions were as low or lower than the EPA recommended maximum allowable concentration in drinking water. The average concentration of suspended solids in the least disturbed areas ranged from 50 ppm for base flow to about 150 ppm for storm runoff. The application of artificial rainfall on reclaimed surface mine lands showed that by crimping straw into a bare, compacted topsoil the water intake was increased by one-third, and with the stablishment of vegetation, the intake rate was doubled for the first inch of rainfall, but was less than the intake of a freshly disked soil.

(*h*) **Research on the Hydrology and Water Quality of Watersheds Subjected to Surface Mining–Phase I: Premining Hydrologic and Water Quality Conditions. (Summary Report).** U.S. Department of Interior, Bureau of Mines Report. (Available through NTIS.) G. E. McIntosh, W. R. Hamon (eds.), Feb. 1979.

300-11393-870-36

DEFINITION OF ANIMAL WASTE CONTRIBUTIONS TO NONPOINT SURFACE RUNOFF

(*b*) Partially supported by EPA and Cooperative with Nebraska Agricultural Experiment Station, Lincoln, Nebraska 68583.

(*c*) John W. Doran, Soil Scientist, 116 Keim, University of Nebraska, Lincoln, Nebr. 685,83.

(*d*) Experimental, field investigation; basic and applied research.

(*e*) Objectives are to determine the effect of livestock grazing on the physical, chemical, and bacteriological quality of runoff water. The pasture watershed, over 100 acres, is grazed by 35 to 45 cow-calf pairs. Small, fenced areas are used to establish a background level for runoff water quality without cattle grazing. Automatic sampling devices collect runoff samples at programmed intervals and flumes measure runoff during an event.

(*g*) Runoff water quality from the cow-calf pasture has been generally comparable with runoff from other agricultural nonpoint sources. Concentrations of NO_3^--N, NH_4^+-N, and soluble P range from 0.5 to 2.8, 0.2 to 3.0, and 0.8 to 3.2 mg/liter, respectively. The concentrations of soluble and particulate forms of N, P, and C were significantly higher in runoff from the ungrazed control than from the adjacent grazed pasture, but runoff from both was within water-quality standards. Stocking rate had a direct influence on the NO_3^--N, souble P, TOC, COD, and Cl^- concentrations in rainfall runoff. Grazing cattle also contributed significantly to fecal coliform counts, while wildlife contributed to fecal coliform and fecal streptococci counts in runoff water. The bacteriological counts for indicator organisms in runoff from both grazed and ungrazed pasture exceeded recommended recreational water-quality standards over 90 percent of the time. Concentrations of microbial indicators, NH_4^+-N, NO_3^--N, COD, TOC, and sediment, in runoff from the pasture decrease with time after early peak flow. Concentrations of soluble phosphorus do not appear to be markedly influenced by time and volume of discharge. Much of the total nitrogen is in the organic form and appears to be associated with plant material since runoff samples contained little or no sediment. The results of this 3-year research study emphasize the need to assess the applicability of point-source water-quality standards before use in evaluation of nonpoint sources of pollution.

(*h*) **Bacteriological Quality of Runoff Water from Pasture Land.** J. W. Doran, D. M. Linn, *Abstr., Amer. Soc. Microbiol., Ann. Mtg.*, p. N 23, 1978.

Bacteriological Quality of Runoff Water from Pastureland. J. W. Doran, D. M. Linn, *Applied and Environ. Microbiol.* **37**, May 1979.

Chemical Water Quality from Grazing Land in the Midwest. J. S. Schepers, N. P. Swanson, *Agron. Abstr.*, p. 35 (Presented at Amer. Soc. Agron. Mtg., Chicago, Ill., Dec 1978.) 1978.

Invited presentation, **Agricultural Runoff in the Midwest.** Annual Water Pollution Control Federation Convention, Anaheim, Calif., J. S. Schepers, D. R. Andersen, G. E. Schuman, E. J. Vavricka, H. D. Wittmuss, 1978.

300-11394-870-00

LIVESTOCK FEEDLOT HYDROLOGY AND FACILITIES FOR CONTROL AND UTILIZATION OF RUNOFF AND TRANSPORTED SOLIDS

(*b*) Cooperative with the Nebraska Agricultural Experiment Station, Lincoln, Nebr. 68583.

(*c*) Norris P. Swanson, Research Leader, USDA-SEA-AR, Room 5, Agricultural Engineering, University of Nebraska, Lincoln, Nebr. 68583.

(*d*) Experimental field study, applied research for development and design.

(*e*) Direct discharge and utilization on land of feedlot runoff effluent instead of to a holding pond for later distribution can save both investments and management problems for feeders. Runoff from a three-acre beef feedlot discharges through solids traps onto a one-half mile long, low gradient, grassed waterway in a serpentine or switchback configuration. Instrumentation permits collection of data on the efficiency of the solids traps and the effectiveness of the waterway to infiltrate, dilute, filter, or otherwise reduce the pollution potential of the feedlot runoff.

(*f*) Data collection completed September 30, 1978.

(*g*) Runoff data collected from above-normal rainfall in the summer and fall of 1977 continued to demonstrate the effectiveness of the solids trap and waterway combination for direct disposal and utilization of feedlot runoff. The solids traps have proven to be 70 to 80 percent efficient in removal of settleable solids. Winter snowmelt, the most stringent test of such a system, had a decrease of total solids content from 0.93 percent entering to 0.04 percent at a point less than three-fourth the length of the waterway. Infiltration eliminated possible discharge from the waterway by this event. The COD decreased from 3,070 mg/liter to 118 mg/liter during the same event.

300-11395-870-36

WATER QUALITY AND BEST MANAGEMENT PRACTICES FROM AGRICULTURAL LANDS IN THE MIDWEST

(*b*) Partially supported by EPA and Cooperative with Nebraska Agricultural Experiment Station, Lincoln, Nebr. 68583.

(*c*) J. S. Schepers, Soil Scientist, 113 Keim Hall, University of Nebraska, Lincoln, Nebr. 68583.

(*d*) Experimental, field investigation; basic and applied research.

(*e*) Objectives are to evaluate water quality of runoff from cropland under a variety of Best Management practices as part of the Maple Creek Model Implementation Project (MIP).

(*g*) Funding for water-quality evaluation became available July 1, 1978. Ten sampling sites (flumes) will be instrumented. Rain gauges and automatic water-sampling equipment arrived in September. Instrumentation of one sample site on land having steep-back terraces with an underground tile outlet was completed in the fall of 1978. No runoff has occurred following installation. Seven other sample sites have been selected and are scheduled for instrumentation in the

spring of 1979. Base flow samples collected in the fall from intensive rowcrop farming within the 13,000-ha area averaged 0.92, 2.20, and 0.08 mg/l of NH_4^+-N, NO_3^--N, and soluble P, respectively.

300-11396-870-36

NONPOINT POLLUTION FROM AGRICULTURAL CROPLANDS

(*b*) Partially supported by EPA, Old West Commission, and Cooperative with Nebraska Agricultural Experiment Station, Lincoln, Nebr. 68583.
(*c*) J. S. Schepers, Soil Scientist, 113 Keim Hall, University of Nebraska, Lincoln, Nebr. 68583.
(*d*) Experimental, field investigation; basic and applied research.
(*e*) Objectives are to determine the contribution of agricultural crop production to the biological, chemical and physical aspects of water quality. Automatic sampling devices collect runoff from a 2000 ha watershed during runoff events. Water quality is related to amount and duration runoff events. Water quality is related to amount and duration of rainfall, cropping sequence, and fertilizer and pesticide application.
(*g*) Precipitation for 1978 totaled 82 cm, which is 20 cm above the long-term average for the area and resulted in 20 individual runoff events. The chemical water quality remained within the accepted water-quality standards in spite of two high-intensity storms. One runoff event more than tripled the previous high rate of runoff discharge and resulted in a threefold increase in sediment concentration at peak flow (35,000 mg solids/l). Runoff collected after planting of corn and sorghum contained up to 50 and 11 μg/l of Atrazine and Ramrod, respectively. Other herbicides and pesticides were detected in concentrations less than 3.0 μg/l. Data from several individual events have been statistically analyzed to develop functional relationships between the various chemical and hydrologic parameters. Water quality of runoff during a moderate-sized event could be predicted with r values of at least 0.85 for NO_3-N, soluble P, sediment N and P, COD, and total solids in terms of the flow rate and time during the event. Predictions of water quality during very large events in terms of time and flow rate were not as reliable until total solids concentration was incorporated into the model.
(*h*) **Water Quality Study from Agricultural Lands,** Project Completion Report, Grant No. 10570002, D. R. Andersen, Dept. Civil Engrg., Univ. of Nebraska, Lincoln, Nebr. 68583.

300-11397-830-00

BASINS FOR RUNOFF AND EROSION CONTROL ON CROPLAND WITH STEEP, IRREGULAR TOPOGRAPHY

(*b*) Cooperative with the Nebraska Agricultural Experiment Station, Lincoln, Nebr. 68583.
(*c*) Norris P. Swanson, Research Leader, USDA-SEA-AR, Room 5, Agricultural Engineering, University of Nebraska, Lincoln, Nebr. 68583.
(*d*) Experimental field study; applied research for development and design.
(*e*) Small land areas often contribute major sediment production within a watershed. Particularly where conservation practices are lacking and undulating topography and slopes are such that terraces cannot be installed and farmed with reasonable effort. Basins impound runoff and control discharge through riser inlets and underground pipe. Bedloads and suspended sediments are deposited on the inundated area. Field type of row-crop farming on steep irregular slopes (Missouri Valley deep loess) were selected on two farms. One small, untreated watershed on each field was instrumented with a flume and an automated, programmed sampler to measure runoff and soil loss. Basins with selected designs and spacings on the subwatersheds permit evaluation of soil movement and loss, runoff, and the effect on soil water, crop production, and managment.
(*g*) High-intensity rainfall produced periods of runoff with soil losses of 20 tons per acre inch of runoff from row-cropped areas without conservation measures. Runoff discharges from recently installed basins had greatly reduced solids content. Samples of discharge taken after inundation of soil surfaces in the basins had even lower solids contents. The farmer had no machine operation problems in his first experience with the "discontinuous terraces."

300-11398-820-00

INVESIGATIONS IN WATERSHED SUBSURFACE HYDROLOGY

(*c*) C. R. Amerman, Research Leader, Watershed Research Unit, 207 Business Loop 70 East, Columbia, Mo. 65201.
(*d*) Experimental, applied.
(*e*) Determine mechanisms by which subsurface water is recharged, moves in the subsurface, and is discharged to the surface. Estimate and predict subsurface flow paths, flow velocities, and rates of recharge and discharge. Investigate quantitative effects of subsurface flows upon stream flow and water yield.

300-11399-810-00

PREDICTING STREAM FLOW FROM LOESSIAL WATERSHEDS IN IOWA AND MISSOURI

(*c*) A. T. Hjelmfelt, Jr., Hydraulic Engineer, Watershed Research Unit, 207 Business Loop 70 East, Columbia, Mo. 65201.
(*d*) Experimental, applied.
(*e*) Develop techniques and models to predict water movement in and stream flow from small watersheds. Evaluate factors that determine stream flow characteristics on loessial watersheds in order to enhance agricultural production.
(*h*) **Influence of Infiltration on Overland Flow,** A. T. Hjelmfelt, Jr., *J. of Hydrology 36:179-185*, 1978.

300-11400-810-00

BEHAVIOR AND MOVEMENT OF AGRICULTURAL CHEMICALS IN DEEP LOESS SOILS

(*c*) R. E. Burwell, Watershed Research Unit, 207 Business Loop 70 East, Columbia, Mo. 65201.
(*d*) Experimental, applied.
(*e*) To determine the effect of mulch tillage on chemical losses in surface runoff; the enrichment of nitrogen and phosphorus in sediment; and the subsurface movement of nitrate in the soil.
(*h*) **Seasonal Runoff Losses of Nitrogen and Phosphorus from Missouri Valley Loess Watersheds,** E. E. Alberts, G. E. Schuman, R. E. Burwell, *J. Environ. Qual. 7(2):203-208*, 1978.

300-11401-810-00

PREDICTING STREAM FLOW FROM CLAYPAN WATERSHEDS IN MISSOURI

(*c*) L. A. Kramer, Watershed Research Unit, 207 Business Loop 70 East, Columbia, Mo. 65201.
(*d*) Experimental, applied.
(*e*) Evaluate factors that determine stream flow quantity characteristics on claypan soil watersheds. Predict water movement in and stream flow from agricultural watersheds. Evaluate the management and utilization of stream flow for agricultural production.

300-11402-810-00

MOVEMENT OF CHEMICALS FROM CROPLAND AS AFFECTED BY AGRONOMIC PRACTICES FOR CLAYPAN SOILS

(*c*) R. E. Burwell, Watershed Research Unit, 207 Business Loop 70 East, Columbia, Mo. 65201.
(*d*) Applied.
(*e*) Establish a permanent record of information collected from 40 plots on a claypan soil near Kingdom City

(formerly McCredie), Missouri, from 1941 through 1977 for evaluating the effects of managment on runoff, erosion, water quality and crop production.

(*h*) **Fertilizing Corn Adequately with Less Nitrogen.** F. D. Whitaker, H. G. Heinemann, R. E. Burwell, *J. Soil and Water Conserv. 33(1):28-32*, 1978.

300-11403-860-00

SEDIMENTATION AND EUTROPHICATION IN SMALL RESERVOIRS

(*c*) David L. Rausch, Watershed Research Unit, 207 Business Loop 70 East, Columbia, Mo. 65201.
(*d*) Experimental, field, applied.
(*e*) Determine quantities of sediment and nutrients trapped in small reservoirs on a storm basis, how these quantities can be reduced, and the effect of a bottom-withdrawal spillway on water quality in the reservoir and downstream.
(*h*) **Optimizing Water Quality Using Small Reservoirs,** H. G. Heinemann, D. L. Rausch, *Proc. 32nd Ann. Mtg. SCSA*, Richmond, Va., pp. 85-92 (1977).

300-11404-830-00

IDENTIFICATION OF PROCESSES OF SHEET-RILL EROSION AND SEDIMENT MOVEMENT FROM FARM FIELDS

(*c*) R F. Piest, Watershed Research Unit, 207 Business Loop 70 East, Columbia, Mo. 65201.
(*d*) Experimental, applied.
(*e*) Quantify erosion rates and determine the kinematics of soil detachment, transport, and deposition on agricultural fields. Modify or refine the Universal Soil Loss Equation to better fit measured storm soil losses on research plots and transects. Define prediction accuracies of resulting sediment yield model.

300-11405-830-00

EFFECT OF SURFACE RUNOFF ON GULLY GROWTH IN THE MISSOURI BASIN DEEP LOESS REGION

(*c*) R. F. Piest, Watershed Research Unit, 207 Business Loop 70 East, Columbia, Mo. 65201.
(*d*) Experimental, applied.
(*e*) Define threshold runoff levels that cause gully erosion; develop practical procedures for estimating future rates of gully development so that optimum controls can be effected.

300-11406-830-00

IMPROVED GULLY BANK STABILITY TO CONTROL AND REDUCE EROSION AND SEDIMENTATION

(*c*) R. F. Piest, Watershed Research Unit, 207 Business Loop 70 East, Columbia, Mo. 65201.
(*d*) Experimental, field, applied.
(*e*) Define the probability of gully bank failure resulting from changes in soil strength and imposed stresses. Develop procedures to control the variables that cause gully bank instability and thereby reduce erosion rates from fields.

300-11407-830-00

PREDICTING CHANNEL PROFILES AND SOIL TRANSPORT FROM RECONSTRUCTED SEQUENCES OF CHANNEL EROSION

(*c*) R. F. Piest, Watershed Research Unit, 207 Business Loop 70 East, Columbia, Mo. 65201.
(*d*) Field, applied.
(*e*) Use the time-space sequency of channel erosion in the Missouri Basin loess hills region to predict future channel degradation and to effect optimum channel controls.

300-11408-830-00

DEVELOP IMPROVED SEDIMENT YIELD PREDICTION METHODS FOR CONTEMPORARY SEDIMENT DESIGN PROBLEMS

(*c*) R. F. Piest, Watershed Research Unit, 207 Business Loop 70 East, Columbia, Mo. 65201.
(*d*) Field, applied.
(*e*) Develop an interim or shortcut procedure for estimating average annual sediment yields of a watershed–based upon best utilization of existing records.

300-11409-810-00

IMPROVING RUNOFF AND WATER EROSION CONTROL FOR CORN AND SOYBEAN PRODUCTION SYSTEMS

(*c*) R. E. Burwell, Watershed Research Unit, 207 Business Loop 70 East, Columbia, Mo. 65201.
(*d*) Experimental, applied.
(*e*) Determine the seasonal and long-term effects of recurring tillage and crop residue management practices for corn and soybeans cropped continuously, in rotation, and in multi-cropping with winter wheat or rye on runoff, erosion, and crop yields for claypan soils. Determine the combined effect of no-till planting and double-spaced terraces on runoff and erosion.

U.S. DEPARTMENT OF AGRICULTURE, SCIENCE AND EDUCATION ADMINISTRATION, AGRICULTURAL RESEARCH

NORTHEASTERN REGION, Beltsville Agricultural Research Center, Beltsville, Md. 20705.

301-09276-810-00

PREDICTING THE EFFECT OF LAND USE ON WATERSHED HYDROLOGY AND WATER QUALITY IN THE NORTHEAST

(*b*) Cooperative with The Pennsylvania State University, Agricultural Experiment Station.
(*c*) Dr. Harry B. Pionke, Soil Scientist, Northeast Watershed Research Center, 110 Research Building A, University Park, Pa. 16802.
(*d*) Experimental and field investigation; applied research, development.
(*e*) The hydrologic and water quality processes and parameters critical to the analysis and resolution of land use–water resource problems in the Northeast are being identified and evaluated. The research results are being formalized so that they are directly available as a planning or management tool. The study sites that are part of the program include research agricultural watersheds, strip-mines, porous asphalt and drainage plots.
(*g*) A simple physically based watershed model has been developed to simulate the electrical conductivity variations of streamflow. The model identifies and estimates the impact of the dominant hydrologic and chemical interactions controlling water quality variations at the outlet of a small watershed during the storm. Field-based hydrologic measurements were demonstrated as potentially useful for accurately estimating chemical transport in perched groundwater systems. Water movement through perched water tables in soil and fractured rock zones were traced successfully by chemical tracers. The principal sources of baseflow and dissolved chemicals found in upland streams of the Northeastern U.S. appear to be these perched groundwater zones. New concepts useful for improving the modeling of snow accumulation, melt and drainage from the snowpack as a function of elevation have been established. Data from mountain network precipitation gages and snow courses shows increased intensity of concurrent hourly precipitation with elevation. Increased duration accounts for a minor part of the elevation effect. For the first time, it has been demonstrated in the field that due to air entrapment, considerable air pressure is

built up in soils having a flow-restricting subsurface layer. These findings show that relieving soil air pressure will decrease runoff and erosion hazards from soils with subsurface flow restrictions such as fragipan or high water tables. Porous asphalt has been demonstrated in the field as an effective method of reducing runoff and increasing groundwater recharge. There was no runoff from the plot during 1978 despite several intense rainstorms with 70-80 percent of the long-term precipitation being recharged. Severe freeze-thaw conditions did not physically damage the porous asphalt plot.

(*h*) **Modeling Storm Hydrograph Water Quality–A Partial Area Approach,** W. J. Gburek, *Ph.D. Thesis in Civil Engineering*, Pennsylvania State University, 224 pp., 1978.

Use of Neutron Activatible Tracers for Simulating Water and Chemical Flow Through Porous Media, F. G. Haaser, W. A. Jester, W. R. Heald, A. S. Rogowski, H. B. Pionke, J. B. Urban, Institute for Research on Land and Water Resources, The Pennsylvania State University, 306 pp., 1978.

Influence of Subsurface Drainage on Soil Air and Infiltration: In Sand, A. R. Jarrett, J. R. Hoover, C. L. Davis, *ASAE Paper 78-2039*, 1978.

Evaluating the Effect of Increased Concentrations of CO_2 on Infiltration Rate, A. R. Jarrett, J. R. Hoover, *ASAE Paper 77-2254*, 1977.

The Role of Elevation in Modeling Spatial Distribution of Precipitation, Snow Accumulation and Melt, and Water Input, R. L. Hendrick, S. L. Dingman, *Proc. Workshop on Modeling of Snow Cover Runoff*, Hanover, N.H., Sept. 1978. AGU, AMS, Corps of Engrs., and NWS.

Annual and Season Precipitation and Streamflow as a Function of Elevation in New Hampshire and Vermont, S. L. Dingman, R. L. Hendrick, *Proc. Workshop on Modeling of Snow Cover Runoff*, Hanover, N.H., Sept. 1978. AGU, AMS, Corps of Engrs., and NWS.

Effect of Elevation on Snowfall and Rainfall–Final Results from the Mt. Mansfield Network, R. L. Hendrick, D. B. Heath, *Proc. 1978 Eastern Snow Conference*, Hanover, N.H., Feb. 2-3, 1978.

Storm Water Detention and Groundwater Recharge Using Porous Asphalt–Experimental Site, J. G. Urban, W. J. Gburek, *Proc. Intl. Symp. Urban Storm Runoff*, Lexington, Ky., July 23-26, 1979.

Storm Water Detention and Groundwater Recharge Using Porous Asphalt–Initial Results, W. J. Gburek, J. B. Urban, *Proc. Intl. Symp. Urban Storm Runoff*, Lexington, Ky., July 23-26, 1979.

301-10622-810-00

PREDICTING THE EFFECTS OF LAND USE AND MANAGEMENT ON RUNOFF AND WATER YIELD

(*b*) Cooperative with the University of Maryland, College Park, Maryland and Virginia Polytechnic Institute and State University, Blacksburg, Va.

(*c*) Dr. E. T. Engman, Chief, Hydrology Laboratory, Plant Physiology Institute, Northeastern Region, SEA-AR, Beltsville, Md. 20705.

(*d*) Basic and applied research.

(*e*) The mission of the USDA-SEA Hydrology Laboratory is to conduct research on methodology for predicting and evaluating water yield from large areas in the United States and to work directly with the USDA Soil Conservation Service and other action agencies in the development and transfer of current research results for their immediate use. The Hydrology Laboratory functions as a national laboratory by extending and modifying the research results from local and regional studies to broader geographical areas. Research emphasis is placed on determining the effects of land use, climate variability and hydrologic variability on water yield from large areas. An interdisciplinary approach to the problem is being used and relies heavily on mathematical modeling, sensitivity analysis and remote sensing.

(*g*) Using data from small watersheds and plots, a procedure has been developed for estimating the effect of conservation tillage practices on SCS runoff curve numbers. Using the amount of residue on the ground or the percent of the surface covered with residue, one can estimate how much the SCS runoff curve number decreases as residue increases. A general relationship was developed to relate the accuracy of percent of impervious area value estimated from Landsat data to the size of the area under investigation. These results showed that Landsat procedures provide estimates of acceptable accuracy for watersheds over one square mile in size. A new reservoir sediment trap-efficiency curve has been developed that estimates less storage requirement for sediment than the trap-efficiency curve extensively used for the past 25 years. Rainfall properties related to flash floods have been characterized. It was observed that the smallest time increments of maximum rainfall are imbedded in the next longer time interval. However, the various short-duration increments from a particular storm rarely have identical frequencies. A method has been developed to independently estimate the S-parameter to the Green and Ampt equation. Statistical estimation of Green and Ampt infiltration equation parameters was obtained from infiltrometer runs where the moisture movement is measured during simulated rain. A subsidence function expressed as an exponential of a parameter combining relative size of storage area, peak inflow and other channel and flow factors was developed to economically estimate the subsidence of peak flow in situations where large storage areas occur. A procedure has been developed for estimating 5-minute increments of rainfall from clock-hour amounts. It was determined that the clock 5-minute amounts are approximately 20 percent less than the period containing the maximum rainfall. Given the position and magnitude of the largest 5-minute amount, a triangular distribution has been proposed as the best fit of the 12 5-minute increments in an hour.

(*h*) The Hydrograph Laboratory maintains current bibliographies and abstracts of papers published since the inception of the Laboratory in 1961. These are available upon request at no cost.

U.S. DEPARTMENT OF AGRICULTURE, SCIENCE AND EDUCATION ADMINISTRATION, AGRICULTURAL RESEARCH

SOUTHERN REGION, P.O. Box 53326, New Orleans, La. 70153. Dr. E. L. Kendrick, Regional Administrator.

302-7002-390-00

DEVELOPMENT OF CONSERVATION STRUCTURES AND WATERFLOW MEASURING DEVICES

See U.S. Department of Agriculture, Science and Education Administration, Agricultural Research, North Central Region, Project 300-01723-350-00.

(*b*) Cooperative with the Oklahoma Agric. Exp. Station, Oklahoma State University, Stillwater, Oklahoma.

(*c*) Dr. W. R. Gwinn, Research Leader, Water Conservation Structures Laboratory, P.O. Box 551, Stillwater, Okla. 74074.

(*d*) Experimental, applied research for development and design.

(*e*) The laboratory conducts hydraulic research to develop basic knowledge for structures and channels used in the measurement, conveyance, storage, and disposal of surplus runoff water. A mathematical model of the earth emergency spillway breaching phenomenon is under study. This model will be descriptive of the relationship of breaching time and hydrograph of flow over the spillway with spillway profile and soil characteristics as parameters. A structural low-drop spillway using a baffle to dissipate energy and control grade in channels is currently under study. A generalized investigation of the riprap requirements for a SAF stilling basin is under study. The head-discharge relationship of sheet pile (Z section) drop structures of the

Taylor Creek Watershed near Ft. Pierce, Florida are being determined using 1:6 models of two sites. These sites are the principal runoff measuring stations for water quality studies on the watershed.

(*g*) A computational procedure for evaluation of vegetal lining in terms of effective tractive force was incorporated in the mathematical model of emergency spillway breaching phenomenon.

(*h*) **Manning n and the Overland Flow Equation,** W. O. Ree, F. L. Wimberley, F. R. Crow, *ASAE Trans.* **20**, 1, pp. 89-95, 1977.

How Accurate are Shop-Made Orifice Plates, W. O. Ree, *ASAE Trans.* **20,** 2, pp. 298-300, 1977.

Annual Grasses for Temporary Protection of Earth Spillways, W. O. Ree, F. R. Crow, W. W. Huffine, *ASAE Trans.* **20,** 5, pp. 934-939, 1977.

Evaluating Components of the USDAHL Hydrology Model Applied to Grassland Watersheds, F. R. Crow, W. O. Ree, S. B. Loesch, M. D. Paine, *ASAE Trans.* **20,** 4, pp. 692-696, 1977.

Land Forming for Border Irrigation, D. M. Temple, *ASAE Trans.* **21,** 5, pp. 907-912, 1978.

302-09286-810-00

PREDICTING RUNOFF AND STREAMFLOW FROM AGRICULTURAL WATERSHEDS IN THE SOUTHEAST

(*b*) Cooperative with the Univ. of Georgia Agric. Exp. Sta., Univ. of Florida Agric. Exp. Sta., Soil Conservation Service, and the South Florida Water Management District.

(*c*) Loris E. Asmussen, Geologist, Southeast Watershed Research Program, USDA-Science and Education Administration, P.O. Box 5677, Athens, Ga. 30604.

(*d*) Experimental, theoretical, and field investigation; basic and applied research.

(*e*) Determine statistics of rainfall and runoff, develop methods to estimate design values of runoff and streamflow for basin development. Build models to predict hydrologic response of watersheds with improved agricultural management. Watershed processes will be conceptualized in mathematical models, each specific to a prediction problem. Models will be verified and improved through field research on agricultural watersheds in the Coastal Plains of the humid Southeast, but centered in Little River, Tifton, Georgia and Taylor Creek, Okeechobee, Florida. Basin precipitation, streamflow, groundwater, and climate data will be processed by mathematical-statistical techniques to develop base data and model components. Mapping techniques will be developed to incorporate physical, geological, and management practice characteristics in the models.

(*g*) A three-component watershed retention function was restructured to partition storm-event rainfall into surface, interflow and base flow, and upper and lower zone storage. An algorithm to predict the effects of farm ponds on the event hydrograph was incorporated into the Southeast Watershed Impact Modeling System (SWIMS). A computerized recursive technique, developed through the use of generating functions, for transforming meteorologic input and state probabilities was adapted and applied for computing probability distribution of annual direct runoff and sediment yield from a 24-sq. mi. watershed near Ahoshie, N.C. Techniques were developed to estimate runoff curve numbers based on Landsat data as potential inputs to hydrologic models. Studies on remote sensing for determination of soil moisture by airborne microwave sensors were initiated, cooperatively with U.S. Hydrology Laboratory and NASA/GSFC. For the 5-year period, 1972-1976, mean annual runoff rate from Little River complex cover agricultural watersheds ranged from 12.4 to 17.6 area-in/year. Mean annual runoff rate for the period was 1.15 cfs/mi^2. Generally, runoff was concentrated in the first 5 months of the year with 75 percent of the total area runoff occurring January-May. For a small, single cover watershed, Station Z, total runoff was partitioned 20 percent surface and 80 percent subsurface flow (1969-1977). Subsurface flow averaged 120 days/yr., while surface flow averaged 1-1/2 days/yr. A report showing engineering design data on seasonal variations in extreme rainfall amounts, quarterly-extreme rainfall-deficient periods, and seasonal occurrence of selected rainfall amounts for the Coastal Plain and Flatwoods of Georgia has been finalized. Analyses of long-term hydrologic and water quality data from Taylor Creek, Okeechobee County, Florida were completed and a comprehensive report has been prepared for publication as a USDA Technical Bulletin. Thermal images by aircraft overflight at 4,500 feet and 9,000 feet were used with ground-based evapotranspiration measurements to predict components of evapotranspiration from two 1 mi.^{2} areas of Taylor Creek Watershed.

(*h*) **Calculation of Temporally and Areally Distributed Rainfall, Closure,** J. D. Dean, W. M. Snyder, *Proc. ASCE, 104(IR4):456*, 1978.

A Unifying Set of Probability Transforms for Stochastic Hydrology, W. M. Snyder, W. C. Mills, W. G. Knisel, Jr., *Water Resour. Bull. 14(1):83-98*, 1978.

Transformation of Hydrologic System Input Probability Distributions for Planning and Design, W. C. Mills, D. R. Davis, *Proc. Am. Geophys. Union, 59(4):272*, 1978.

Fully Computerized Smoothed Data and Gradients Using Sliding Polynomials, W. M. Snyder, *Proc. 14th Amer. Water Resources Conf., Lake Buena Vista, Fla., 1978. (Abstract).*

Flood Peak Regionalization Using Mixed-Mode Estimation of the Parameters of the Log-Normal Distribution, M. L. Shrader, W. M. Snyder, W. J. Rawls, R. H. McCuen, *Proc. 14th Ann. Water Resources Conf.*, Lake Buena Vista, Fla., 1978. (Abstract).

Interfacing a Physically-Based Model With a Parametric Model to Predict Runoff from Ungaged Streams, F. W. Bond, D. L. Chery, Jr., E. S. Simpson, *Proc. Natl. AWRA Conf.*, Tucson, Ariz., Oct. 31-Nov. 3, 1977, p. 2.

Methods of Estimating Evaporation and Evapotranspiration, W. G. Knisel, *FAO Conservation Guide* **2,** Chap. 7, pp. 67-71, FAO, Rome, 1977.

A Shallow Subsurface Flow Model, W. J. Rawls, L. E. Asmussen, *EOS-AGU Abstract*, Spring Meeting, 1978.

Water Quality of Streams on the Upper Taylor Creek Watershed Okeechobee County, Florida, E. H. Stewart, L. H. Allen, Jr., D. V. Calvert, *Soil and Crop Sci. Soc. Fla. Proc. 37:117-120*, 1978.

302-09287-860-00

DEVELOP METHODS FOR EVALUATING, PREDICTING, AND REDUCING POLLUTION OF SOIL, WATER, AND AIR BY AGRICULTURAL CHEMICALS

(*b*) Cooperative with Univ. of Georgia Agric. Exp. Sta., Univ. of Florida Agric. Exp. Stat., Soil Conservation Service, and the Central & Southern Florida Flood Conservation District.

(*c*) Loris E. Asmussen, Geologist, USDA-SEA, Athens, Ga., Southeast Watershed Research Program, P.O. Box 5677, Athens, Ga. 30604.

(*d*) Experimental, theoretical, and field investigation; basic and applied research.

(*e*) Develop methods for evaluating, predicting, and reducing pollution of soil and water by mineral matter and chemicals and model the movement of agricultural minerals and chemicals from and within agricultural land. Concentration and load of chemicals and minerals will be related to hydrologic parameters, cultural practices, and land-physical descriptions.

(*g*) A cooperative study with the University of Georgia has been initiated to focus on processes of nutrient cycling on agricultural watersheds in the Coastal Plain. Investigations will include watershed input-output nutrient budgets, agricultural nutrient contributions, and the role of alluvial vegetation as a filtering mechanism for nutrients migrating toward stream systems. For a small single cover cropped area (0.34 ha), the subsurface flow component was found

to be the primary mechanism for nitrate and nitrite-nitrogen transport. For 1969-1976 less than 1 percent of the N-loss from the area occurred in surface runoff. For a complex cover Coastal Plain watershed, 16.8 km^2, observed runoff loads of NO_3+NO_2-N and ortho-P were only 1.2 percent and 3.0 percent of the estimated rainfall and man-applied amounts. Regression analyses were performed on log transforms of chemical (NO_3+NO_2-N, ortho-P, Cl) concentrations and load vs. flow rate for all Little River watersheds. Chemical rating curves were developed for use in predicting chemical loads in runoff from Coastal Plain mixed cover agricultural watersheds. Results of field studies on atrazine movement for two application rates (2.24 and 4.48 kg/ha) show that atrazine concentrations in the soil decreased rapidly in the first 15 days after application. Initial levels were $\approx$800 μg/l and 1400 μg/l in the top 10 cm of soil. No atrazine was detected at this depth for the 4.48 kg/ha rate. The initial concentration in the surface runoff was $\approx$1200 μg/l for the 4.48 kg/ha rate and $<$400 μg/l for the 2.24 kg/ha rate. Total atrazine loss was 2.2 and 1.1 percent of the applied amount in 1974 and 1975, for the 2.24 kg/ha rate, while losses were 3.4 and 1.6 percent in 1974 and 1975, for the 4.48 kg/ha rate. Probabilistic forecasts of annual sediment yield were computed for a 62 km^2 watershed near Ahoskie, N.C., by using a computerized recursive technique. Sediment yield probability distributions were obtained both for present watershed conditions with conventional tillage and for possible future conversion to minimum tillage. Sediment rating curves were developed by use of regression analyses of sediment concentrations and load data vs. flow data for subwatersheds on Little River. Sediment delivery ratios (SDR) were computed for Station K, a 16.8 km^2 mixed cover agriculture watershed. Annual SDR's were 6.6 and 8.7 percent for 1975 and 1976. Water quality studies on Taylor Creek watershed show orthophosphate-P unit loads were greatest from intensive dairy land use areas followed by beef pasture areas, and least from a beef-citrus area. Discharge of ortho-P appeared to result from a storm flushing action. Nitrate-N unit loads were influenced by land use similarly to ortho-P loads. Chloride concentrations and loads were greatest from a citrus-producing area utilizing saline artesian irrigation waters.

(*h*) **Quality of Agricultural Runoff Water in the Coastal Plain of the Southeast, (Abstract),** L. E. Asmussen, *Proc. Agric. Nonpoint Pollution Conf.*, Gainesville, Fla., Feb. 1979.

302-09290-220-00

EFFECTS OF BED FORMS ON THE SUSPENSION AND BEDLOAD TRANSPORT OF SEDIMENT

(*c*) Joe C. Willis, Research Hydraulic Engineer, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) An analytical and experimental investigation of the stochastic properties of bed forms and the bed material discharge.
(*e*) Statistical descriptions of bed forms along with measurement of the total sand load were obtained for different flows and temperatures in a laboratory test channel. These data were analyzed according to a theoretical derivation of the bed load from bed-form spectra.
(*f*) Completed.
(*g*) The spectral method for calculating the bed load was applied to flume data and the probability density function of the bed surface was used to define a lower suspension reference for sediment suspension models. An analysis of continuous concentration records defined the stochastic properties of the bed material discharge in a laboratory flume.
(*h*) **Sediment Discharge of Alluvial Streams Calculated from Bed-Form Statistics,** J. C. Willis, J. F. Kennedy, *IIHR Rept. No. 202*, 200 p., 1977.
Sediment Transport in Migrating Bed Forms, J. C. Willis, J. F. Kennedy, *Proc. ASCE Hydraulics Div. Specialty Conf.*, pp. 551-560, 1978.
Statistical Analysis of Concentration Records, J. C. Willis, G. C. Bolton, *ASCE J. Hydr. Div.* **104**, HY 11, pp. 1-15, Jan. 1979.

302-09292-200-00

TIME AND SPATIAL DISTRIBUTION OF BOUNDARY SHEAR STRESS IN OPEN CHANNEL FLOWS

(*b*) Cooperative with the University of Mississippi and the U.S. Army Corps of Engineers.
(*c*) C. V. Alonso, Research Hydraulic Engineer, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) Computer-aided experimental studies to determine the spatial distribution of instantaneous shear stress exerted by turbulent flows on open-channel boundaries. These boundary stresses are being measured in an 18-meter recirculating flume using hot-film anemometry techniques. The anemometer signals are digitized in a real-time mode, and subsequently subject to time-series analysis in order to evaluate the stochastic properties of the boundary unit tractive forces.
(*g*) Over fifty runs were made to measure the statistical moment of instantaneous shear stresses along the wetted perimeter of a rectangular open-channel flow with an aspect ratio of 4.4 and a Reynolds number of 170,000. The distribution of relative intensity of the stress fluctuations was found to follow trends similar to those exhibited by the relative mean shear. The coefficients of skewness and kurtosis exhibited marked quasiperiodic spatial variations along the wetted perimeter. The measured probability density functions were positively skewed, with instantaneous standardized stress values ranging from -2.5 to 10.0 times the standard deviation. These density functions were well fitted only by the two-parameter gamma density function.
(*h*) **Some Stochastic Properties of Turbulent Tractive Forces in Open-Channel Flows,** K. F. Wylie, C. V. Alonso, N. L. Coleman, R. Darden, *Proc. 5th Biennial Symp. on Turbulence*, Univ. of Missouri-Rolla, Oct. 1977.

302-09293-220-00

LOCAL FLOW AND FORCES EXERTED ON A STREAMBED PARTICLE

(*c*) N. L. Coleman, Geologist, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Experimental, basic and applied research.
(*e*) Laboratory experiments to determine lift and drag coefficient functions for particles on a streambed. Measurements of drag and lift forces, flow velocities, and other relevant variables are being made during experiments in a water tunnel.
(*f*) Completed.
(*g*) The drag coefficient function for a particle on a streambed was defined for a range of flows from viscous to completely turbulent. Attempts at making reliable lift force measurements were not successful, and were discontinued. In addition to the drag force data obtained in this project, valuable measurements were made of velocity profiles in both viscous and turbulent flows over rough surfaces. These will be the subject of forthcoming reports.
(*h*) **A Streambed Particle Model-Study Facility Using Hydroxy Ethylcellulose Solutions as a Fluid,** N. L. Coleman, W. M. Ellis, *Report ARS-S-147*, 8 pp., Sept. 1976.
Model Study of the Drag Coefficient of a Streambed Particle, N. L. Coleman, W. M. Ellis, *Proc. 3rd Federal Interagency Sedimentation Conf.*, Denver, Colo., pp. 4-1 to 4-5, Mar. 1976.
Extension of the Drag Coefficient Function for a Stationary Sphere on a Boundary of Similar Spheres, N. L. Coleman, *La Houille Blanche* **4**, pp. 325-328, 1977.
Bed Particle Reynolds Modeling for Fluid Drag, N. L. Coleman, *J. Hydraulic Research* **17**, 2, June 1979.

302-09295-300-00

STREAM CHANNEL STABILITY

(*b*) Cooperative with the University of Mississippi, Mississippi State University and the Soil Conservation Service.

(*c*) Dr. Earl H. Grissinger, Soil Scientist and Dr. W. C. Little, Research Hydraulic Engineer, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.

(*d*) Field and laboratory investigations; basic and applied research.

(*e*) Using multivariate statistical techniques, identify the soil physiochemical properties that are significant channel erodibility parameters and statistically relate eroding shear stress to the soil parameters.

(*f*) Completed.

(*g*) Field erodibility studies, using a portable flume, were continued. Analysis of the data at hand indicates the stability of fine grained materials of low plasticity indices cannot be adequately described by the D_{50} value. Sample morphology, clay content, and infiltration (wetting) characteristics influenced the measured erosion rates. In general, the measured erosion rates varied inversely with sample clay content. The rates were excessive for samples which had visible, but small scale, sand lensing or other zones of relative weakness and for samples of low hydraulic conductivity which were initially tested at low antecedent water content. The pin hole test appears to have potential as a "quick" measure of erodibility for materials of this type.

302-09296-220-00

SEDIMENT PROPERTIES THAT AFFECT AGRICULTURAL CHEMICAL TRANSPORT

(*b*) Cooperative with USDA-SEA-AR Sediment Yield and Soil Erosion Research Units, Oxford, Miss.; USDA-SEA-AR Soil and Water Pollution Research Unit, Baton Rouge, La.; USDA Forest Hydrology Laboratory, Oxford, Miss.; and the Mississippi Agricultural and Forestry Experiment Station.

(*c*) L. L. McDowell and J. D. Schreiber, Soil Scientists, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.

(*d*) Laboratory and field investigations; basic and applied research.

(*e*) Determine quantity and forms of farm chemicals transported in surface runoff from upland and Delta croplands; evaluate relative significance of solution-and sediment-phase chemical transport; evaluate minimum tillage practices for reducing chemical losses from farmlands; determine physical and chemical properties of sediments that affect chemical transport; develop sediment-water-chemical relationships needed for predicting the transport of farm chemicals.

(*g*) Progress was made in three areas of farm chemical transport research: 1) estimating soluble phosphorus (PO_4-P) in runoff from croplands; 2) evaluating organic carbon concentrations and yields in runoff from conservation tillage practices; and 3) evaluating toxaphene washoff from plant canopy as a function of rainfall intensity and amount. Predicting soluble PO_4-P concentrations in runoff from croplands on a storm basis must consider a number of complex, interacting P inputs, including soil (sediment), fertilizers, crop residues, and possibly leaching of P from growing crops. Using a simple approach to this problem, equilibrium phosphorus concentration (EPC) values determined from soil P sorption isotherms provided a good estimate of the *annual mean* soluble ortho-P concentrations measured in runoff from Mississippi Delta watersheds, but single storm runoff P concentrations varied appreciably from this mean. On Mississippi upland soils, EPC values predicted the annual mean P concentration within a factor of 2 to 4, even when P was released from crop residues. In north Mississippi, no-till practices significantly reduced the total sediment plus solution losses of P and organic carbon (TOC) in runoff. Concentrations of solution and sediment TOC were greater from pine-forested watersheds than from conventional till and no-till corn, with a greater proportion of the TOC transported in the aqueous phase. Annual average BOD_5 concentrations in runoff from conventional and no-till corn were low (20 and 18 mg/l, respectively). BOD_5 losses were lower from no-till because of the lower runoff volume. Thus, no-till was effective in reducing the carbonaceous loading to surface waters. Using simulated rainfall, toxaphene concentrations in washoff from a mature cotton canopy were independent of rainfall intensity when 2.4 cm of rain was applied at 1.27, 2.5, 5.1, and 10.2 cm/hr. Toxaphene washoff was small, amounting to only 2 percent of the 2.2 kg/ha applied. This information greatly simplifies modeling the movement of toxaphene from plant canopy to soil during natural rainfall when intensities vary greatly within events and from storm to storm.

(*h*) **Callahan Reservoir I. Sediment and Nutrient Trap Efficiency,** D. L. Rausch, J. D. Schreiber, *Trans. Amer. Soc. Agr. Engrs. 20:281-284*, 1977.

Callahan Reservoir II. Inflow and Outflow Suspended Sediment Phosphorus Relationships, J. D. Schreiber, D. L. Rausch, L. L. McDowell, *Trans. Amer. Soc. Agri. Engr. 20:285-290*, 1977.

Aqueous and Sediment-Phase Phosphorus Yields from Five Southern Pine Watersheds, P. D. Duffy, J. D. Schreiber, D. C. McClurkin, L. L. McDowell, *J. Environ. Qual. 7:45-49*, 1978.

Suspended Sediment-Phosphorus Relationships for the Inflow and Outflow of a Flood Detention Reservoir, J. D. Schreiber, D. L. Rausch, *J. Environ. Qual.* **8**, 1979.

302-09297-220-00

SEDIMENT DEPOSITION

(*b*) Cooperative with the University of Mississippi, the Mississippi Agricultural and Forestry Experiment Station, University of Wisconsin-Madison, University of Minnesota-Minneapolis, the Great River Environmental Action Team I, the Vicksburg, District, U.S. Army Corps of Engineers, and the U.S. Soil Conservation Service, Jackson, Mississippi and St. Paul Minnesota.

(*c*) Roger McHenry, Soil Scientist; F. E. Dendy, Hydraulic Engineer; J. C. Ritchie, Soil Scientist; F. R. Schiebe, Hydraulic Engineer; C. M. Cooper, Biologist; J. May, Chemist; USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.

(*d*) Experimental laboratory and field studies; basic and applied research.

(*e*) Evaluate watershed, reservoir, hydrologic, hydraulic, chemical, and microbiological parameters which affect, or are affected, by the rates, amounts, character and areal distribution of sediment in reservoirs, lakes, streams, estuaries and valleys. Study the biochemical, physiochemical, and geohydrological aspects of sediment-water systems in lakes, impoundments, and estuaries and relate these to management techniques. Design, develop, test, evaluate, modify, and adapt techniques, methods and instrumentation to characterize significant variables in sediment-water systems in field and laboratory. Compile and analyze existing reservoir sedimentation data including trap efficiency percentages directly by inflow and outflow measurements and indirectly using nuclear and remote sensing techniques. Sedimentation rates and ages are determined by nuclear means and remote sensing techniques are applied to re-evaluation of sedimentation data. Data collection automation and mathematical modeling by digital computer of sedimentation rates and parameters are essential.

(*g*) For a number of years the trap efficiencies of small (agricultural) reservoirs have been measured and published. These data indicate that most structures trap 80 to 95 percent of the inflowing sediment with virtually all the sand-sized material being trapped. The location and distribution of sediment deposits within the reservoirs varies widely. For those reservoirs which are normally dry between runoff events, the efficiency of sediment trapping is greater than where a conservation pool exists. During this report period studies at two small SCS sediment detention structures were terminated. Samples had been

taken to determine volume and particle size of the deposits. Computations are completed but data analysis is still incomplete. In cooperation with other research units in the Sedimentation Laboratory, a small sedimentation detention reservoir located within the Goodwin Creek watershed (908-20808) was selected for study. The objective is to study the behavior of fine silt and clay particles in reservoirs. Laboratory model studies are also continuing. Sediment basins, serving as in-stream sediment traps, are being evaluated for the SCS on Chicod Creek, North Carolina. We continued in the use of the Cs-137 method to determine sediment deposition rates, recent sediment deposition rates, recent sediment age and field erosion rates. In a statistical study we determined that although different individual variables were important in explaining the variation of Cs-137 in soils and sediments three basic factors interact to explain most of the data variation. These are: (1) a rainfall-erosion factor, (2) a site for absorption of Cs-137, and (3) a measure of input of radioactivity into the watershed. Sedimentation rates were determined in two Wisconsin flowage reservoirs, Pigeon River Lake (Waupaca Co.) and Apple River Lake (Polk Co.). The Pigeon River Lake data indicated an increase in recent years of channel erosion whereas the Apple River Lake data showed considerable recent upland erosion. A similar study was conducted on Wolf Lake, Yazoo Co., Mississippi where sediment accumulation rates have exceeded 5.0 cm/year in the upper reaches. In the middle lake the rate was down to 2.5 cm/year in the upper reaches. In the middle lake the rate was down to 2.5 cm/year and at the lower end near 1.0 cm/year. These sediments were mostly clays (up to 80% < 2μ). We have concluded the sedimentation rate studies on the Upper Mississippi River in cooperation with GREAT-I. Final reports were submitted on Pool 8 and Lake Pepin; these reports are being prepared as journal manuscripts. The hydrological, chemical, and biological assessment of Bear Creek Watershed and Lake Chicot continued. Automatic data collection was continued throughout the year. These data are in the process of being summarized and evaluated. Conversion of concentration data to chemical loading is underway. The biological data indicated that in 1978, as in 1977, that the quality of water (in both watersheds) was poor and primary and secondary production was low. At Lake Chicot, primary production on the lower lake did not commence until the turbidity decreased in late summer. With the normal turnover of the lake shortly thereafter total production was a fraction of that in the upper lake. Measurements of precipitation, runoff, sediment and chemicals from single cover (cotton) watershed were continued. Precipitation was 6 inches below average. The runoff was some 19.5 inches with a sediment yield average of 2.6 T/ac/yr. Some 80 percent of the runoff and 96 percent of the sediment yield occurred in January, April, July, and November. The maximum sediment concentration was 0.3 T/ac/inch of runoff in April. Runoff was twice as great in July but the sediment loss was only 0.14 T/ac/inch. Concentrations of P, N, and pesticides (chlorinated hydrocarbons) varied widely during storms and between storms. Randomly selected soil samples showed residual concentrations of toxaphene ranging from 21 to 2270 ng/g and DDT from non-detected to 476 ng/g. Neither pesticide had been applied for several years but significant amounts appear in storm runoff.

(*h*) **Abundance and Production of Littoral and Profundal Benthic Fauna in a Flood Control Reservoir,** C. M. Cooper, *Proc. Ann. Mtg. Mississippi Chap. Amer. Fisheries Soc.*, pp. 25-33, 1977.

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302-09298-830-00

SOURCE AND MAGNITUDE OF SEDIMENT FROM SMALL WATERSHEDS

(*b*) Cooperative with Mississippi Agricultural and Forestry Experiment Station, the Soil Conservation Service, and the Corps of Engineers.
(*c*) Calvin K. Mutchler, Research Leader, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Experimental; applied and basic research.
(*e*) Develop methods for describing and controlling the movement of water and sediment from upland, field, and channel sources to a watershed outlet. The field facilities are 1) Pigeon Roost Creek Watershed in North Mississippi, consisting of ten subwatersheds covering 117 square miles; 2) six flatland watersheds in the Mississippi Delta, a divided one of 83 acres, a natural Delta watershed of 640 acres, two 7-acre graded field segments and two 5-acre ungraded fields; 3) erosion plots sited on the North Mississippi Branch Experiment Station; and 4) a rainulator and computer facilities shared with other research units at the Laboratory. Primary objectives of the research are to document runoff and sediment yield from watersheds under changing cover and agricultural usage; to determine delivery ratios and other sediment yield prediction methods; to develop methods for controlling erosion from farm fields and other watershed sediment sources; to investigate hydraulic and hydrologic effects of channel dredging; to investigate vegetative methods of controlling streambank erosion.
(*g*) Calculations made using rainfall data from a network of 30 raingages indicated that previously published R-factor values for northern Mississippi and possibly other parts of the mid-South are too low. Erosion plot results from simulated rainfall indicated that erosion is proportional to slope-length to the 0.03 power for dry conditions and 0.15 power for wet conditions on 0.2 percent slopes. These values are less than the 0.2 power presently used in the USLE.
(*h*) **Basin Sediment Yield Modeling Using Hydrological Variables,** C. A. Onstad, A. J.Bowie, *Proc. Symp. Erosion and Solid Matter Transport in Inland Waters, IAHS-AISH Pub. No. 122*, p. 191-202, 1977.
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302-10630-220-00

COMPUTER SIMULATION OF LOCALIZED SCOUR AROUND OBSTRUCTIONS IN ERODIBLE-BED CHANNELS

(*b*) Cooperative with the University of Mississippi.
(*c*) C. V. Alonso, Research Hydraulic Engineer, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Theoretical; basic and applied research.
(*e*) Development of a three-dimensional finite-element model to calculate the erosive flow pattern around bridge piers, spur dikes, and similar obstructions in alluvial channels. The purpose of the model is to predict the evolution in time of the scour around structures so that they can be designed against undermining and failure.
(*g*) A Finite Element Model has been developed which is based on the method of weighted residuals and uses variational functionals derived from the shallow-water approximations of both the mass conservation and momentum balance equations for sediment-laden water. These functionals are supplemented with equations for the bed material transport rate, bottom shear, and effective stresses on vertical planes. A system of hexahedral elements has been designed that allows quadratic interpolation functions for the velocity field and linear interpolation functions for the pressure field, to ensure uniform accuracy.
(*h*) **Finite Element Modeling of Flow Around an Open Channel Obstruction,** C. V.Alonso, S. Y. Wang, *Proc. 2nd Intl. Conf. Finite Elements in Water Resources*, Imperial College, London, July 1978.

302-10631-810-00

COMPUTATIONAL MODELS FOR ROUTING WATER AND SEDIMENT IN AGRICULTURAL WATERSHEDS AND ASSOCIATED STREAM-CHANNEL SYSTEMS

(*b*) Cooperative with the University of Mississippi and the U.S. Army Corps of Engineers.
(*c*) C. V. Alonso and D. G. DeCoursey, Research Hydraulic Engineers, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Theoretical; applied research.
(*e*) Develop a continuous simulation watershed model that will include water and sediment components. The model will be oriented towards providing planners with an adequate tool to assess alternative watershed management practices. Computational modeling techniques will be used to simulate the physical processes by which water and sediment move from the upland areas down to the channels draining the watersheds. The processes to be modeled include rainfall interception, runoff, infiltration and groundwater movement, evapotranspiration, sediment production due to raindrop impact, sheet erosion and streamflow entrainment, and movement of water and sediment through the channel system.
(*g*) A hydrology-erosion model has been developed that simulates the movement of water and sediment as a time and space distributed process. Its applicability is restricted, so far, to watersheds where the streamflows are ephemeral, and the subsurface flow and groundwater movement are not significant. The infiltration process is simulated by using the efficient two-parameter model developed by Smith and Parlange (Water Resources Research, June 1978). Water and sediment are routed using numerical scheme based on an analytical solution to the kinematic-wave approximation of the equations of motion. The sediment transport capacity of runoff and streamflows is computed using several transport formulas incorporated in the models. These formulas were selected from a number of transport theories that were examined with reference to flume and field data. The formulation of this single event model has been completed, and a user's manual on the computer program is being prepared. The model has been successfully tested on several field applications.
(*h*) **Field Test of a Distributed Sediment Yield Model,** C. V. Alonso, D. G. DeCoursey, S. N. Prasad, A. J. Bowie, *Proc. 26th Ann. Hydraulics Div. Specialty Conf.*, University of Maryland, pp. 671-678, Aug. 1978.

302-10632-830-00

SOIL EROSION PRINCIPLES AND PROCESS

(*b*) Cooperative with the Mississippi Agricultural and Forestry Experiment Station.
(*c*) L. D. Meyer, Agricultural Engineer, and M. J. M. Romkens, Soil Scientist, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Analytical, experimental, and field studies; basic and applied research.
(*e*) Investigate basic principles and processes of soil detachment, transport, and deposition by rainfall and upland runoff. Study water movement across and into the soil as it affects erosion and runoff rates. Evaluate erosion, runoff, and sediment characteristics for typical land uses. Develop improved methods of predicting soil erosion and infiltration rates. Design improved equipment to conduct soil erosion research. Identify soil characteristics that influence soil erosion and infiltration. Develop better management practices for controlling upland soil erosion by water.

(*g*) Row sideslope erodibility and sediment size distribution were evaluated for 10 soils at 4 rain intensities. Several soils were studied with and without cotton canopy, and one soil was studied at 4 crop stages. Erodibility and sediment size distribution varied considerably from soil to soil, and sediment from some soils was often much larger than their primary particles due to aggregation. A study was started to evaluate the transportability of different sizes of sediment along crop row furrows for different flow rates and furrow steepnesses with and without rainfall. Soil and herbicide losses were measured for seedbed conditions of 4 soybean cropping systems. Hydraulic conductivity measurements of a fragipan soil showed a very slowly drying soil profile due to restricted internal drainage. Soil-water changes in a cotton field were governed by the interplay of rainfall effects and evapotranspiration in the 0 to 15-inch root zone and by crop transpiration demand in the deeper root zone. Various properties of soil surface seals were tested as inputs into infiltration models. Seal conductivity showed the greatest effect on water intake.

(*h*) **Cover, Slope, and Rain Intensity Affect Interrill Erosion,** W. C. Harmon, L. D. Meyer, *Proc. MS Water Resources Conf.*, MS Resources Research Inst., MS State Univ., MS State, MS 8:9-16, 1978.
Soil Erosion Control on Construction Sites with Portland Cement, M. J. M. Romkens, C. B. Johnson, D. W. Nelson, *J. Soil and Water Conservation 33:232-235*, 1978.
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Erodibility of Selected Clay Subsoils in Relation to Physical and Chemical Properties, M. J. M. Romkens, C. B. Roth, D. W. Nelson, *Soil Sci. Soc. Amer. J. 41:954-960*, 1977.

302-10634-810-00

MODELING STORM RAINFALL PATTERNS IN THE SOUTHERN GREAT PLAINS

(*c*) Dr. A. D. Nicks, Agricultural Engineer, USDA, Science and Education Administration, P.O. Box 400, Chickasha, Okla. 73018.
(*d*) Field studies and analysis; basic and applied research.
(*g*) A storm severity index for classifying the runoff producing potential of thunderstorms was developed using intensity data. Sixteen years of records at 20 stations at Chickasha, 20 years at Guthrie, and 26 years at Cherokee, Okla., were analyzed. The severity index and its frequency were calculated. The most severe storm event (1 in 1500 storms) would produce runoff 5 times greater than the amount of rainfall infiltrated into the soil. The most severe intensity occurs in the 1st quartile of storm duration.

302-10635-810-00

PREDICTING SEDIMENT YIELDS FROM LARGE AGRICULTURAL WATERSHEDS

(*c*) P. B. Allen, Hydraulic Engineer and N. H. Welch, Soil Scientist, USDA, Science and Education Administration, P.O. Box 400, Chickasha, Okla. 73018.
(*d*) Field studies and analysis; basic and applied research.
(*e*) Develop a sediment prediction model capable of predicting sediment yield from large (20 to 200 square miles) agricultural watersheds in the Southern Plains. The model will be able to predict storm sediment yield under different basin management patterns by particle sizes, and from reasonable available input data.
(*g*) Evaluation of the WASEG runoff and sediment yield model (under development at Colorado State University) was started using data from a 7.7 ha watershed. Because predicted runoff rates and volumes were very low, the infiltration routine was replaced with an empirical relation of infiltration vs. soil moisture. This improved runoff prediction accuracy. The standard error of estimate improved to 0.336 where the variance of the measured data was 0.369. With the exception of the added empirical infiltration routine, the runoff portion of the model is fully deterministic, however, the sediment prediction portion requires calibration of two parameters. This calibration has not been done, however runs were made with values determined by CSU for two U.S. Forest Service watersheds in Northern Arizona. Sediment predictions were about 100 times too high, indicating that these are very sensitive parameters and suggests that predicted sediment yields will rarely approach the accuracy of runoff predictions.
(*h*) **The Modified Chickasha Sediment Sampler,** P. B. Allen, N. H. Welch, E. D. Rhoades, C. D. Edens, G. E. Miller, *USDA, ARS-S-107*, 13 pages.

302-10636-810-00

PREDICTION OF SEDIMENT YIELDS FROM SMALL AGRICULTURAL WATERSHEDS IN THE SOUTHERN PLAINS

(*c*) N. H. Welch, Soil Scientist, and P. B. Allen, Hydraulic Engineer, USDA, Science and Education Administration, P.O. Box 400, Chickasha, Okla. 73018.
(*d*) Field studies and analysis; basic and applied research.
(*e*) Utilize hydrologic data collected from several small unit source watersheds representing various land uses and other sediment source areas to predict sediment yield from small agricultural watersheds. The watersheds include cropland, rangeland, and gullied areas ranging in size from 12 to 45 acres for the cropland and rangeland, and less than 10 acres for the gullied area. The cropland areas are in alluvial soils and consist of dryland and irrigated row crops and dryland winter wheat. The rangeland areas are in good to excellent and poor to fair range condition. Techniques developed on the small watersheds will be used with data from a 35-square-mile subdivided watershed to predict sediment yield from larger and more complex watersheds. The purpose of the work is to develop procedures to predict the amount, rate, source, and character of sediment yield from agricultural watersheds.
(*g*) Sediment yield estimates by the Modified Universal Soil Loss Equation (MUSLE) and erosion estimates by the Universal Soil Loss Equation (USLE) were compared with measured yields from 12 watersheds for an 11 year period. The MUSLE underestimated average yields on the cropland watersheds, where slopes are less than 1 percent by a factor of 1.7 to 3.2 and overestimated average yields on the rangeland watersheds by a factor of 2.6 and 7.3. The USLE erosion estimates on the cropland watersheds were 1.8 to 6.0 times higher than measured yields and were 3.2 to 45.5 times higher on the rangeland watersheds.
(*h*) **Sediment Yield Characteristics from Unit Source Watersheds,** pp. 125-129. In: *Present and Prospective Technology for Predicting Sediment Yield and Sources*, E. D. Rhoades, N. H. Welch, G. A. Coleman, *ARS-S-40*, 285 pages, 1975.
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302-10637-870-00

CHEMICAL TRANSPORT FROM AGRICULTURAL WATERSHEDS

(*c*) Dr. R. G. Menzel, USDA, Science and Education Administration, 801 Wilson Street, Durant, Okla. 74701.
(*d*) Field studies and analysis; basic and applied research.
(*e*) Chemical content of water and sediment from various watersheds at Chickasha as well as data in the literature will be used to evaluate existing chemical transport models. Tracers and various chemical analyses will be used to measure and characterize leaching, base flow, and groundwater movement. Additional data indicated by the models will be collected to further verify and improve the models. Purpose of the work is to test, modify or develop models for predicting various chemical pollutants in surface runoff, base flow, groundwater, and sediment from agricultural watersheds.
(*g*) Simplified relations were developed for predicting (1) enrichment of nutrients transported with sediment, and (2)

leaching of nitrate. The enrichment ratio decreases logarithmically with increasing amount of sediment for a wide range of soil types and land uses. Nitrate leaching is predicted from the N mineralization potential, temperature, and moisture of the soil, combined with computed movement of water in the soil. These relations will provide a basis for predicting water quality effects of "best management practices."

(*h*) **Models for Predicting Water Pollution from Agricultural Watersheds,** M. H. Frere, *Proc. IFIP Conference*, North Holland Publishing Co. (1978).

Nitrogen Forms and Cycling in Relation to Water Quality, R. G. Menzel, *Proc. Natl. Conf. Manage. Nitrogen Irrigated Agric.*, pp. 33-52, Univ. California, Riverside (1978).

Oxidative Release of Potentially Mineralizable Soil Nitrogen by Acid Permanganate Extraction, G. Stanford, S. J. Smith, *Soil Sci. 126:210-218* (1978).

302-10638-810-00

DEVELOPMENT AND EVALUATION OF HYDROLOGIC MODELS FOR WATERSHEDS IN THE SOUTHERN GREAT PLAINS

(*c*) Dr. A. D. Nicks, Agricultural Engineer, and G. A. Gander, Mathematician, USDA, Science and Education Administration, P.O. Box 400, Chickasha, Okla. 73018.

(*d*) Field studies and analysis; basic and applied research.

(*e*) Various existing continuous simulation models will be tested with data for Southern Great Plains watersheds ranging in size from 10 to 250,000 acres and containing various soils and land uses. The responses of the models to a range of climatic conditions will be tested by using 10 to 15 years of recorded observations. The sensitivity of various model parameters to the climatic and physiographic characteristics of the region and the criteria for selecting values of model parameters will be determined, as well as evaluating the accuracy of the simulated results. Modifications of the models will be coordinated with the testing and development of chemical and sediment transport models to assure compatibility. The purpose of the work is to evaluate and develop continuous simulation models for predicting the water resources of large Southern Great Plains watersheds with mixed and changing land use, and for predicting water movement associated with chemical and sediment transport.

(*g*) The SCS curve number model for field size areas has been tested on watersheds at Guthrie and Chickasha, Okla. The model accurately predicts the long-term mean runoff and extreme events. There is no significant difference between event frequency curves for observed and predicted records.

(*h*) **Development and Evaluation of Environmental Model Parameters: A Case Study Using the USDAHL Hydrologic Model on Watersheds in the Southern Plains,** A. D. Nicks, G. A. Gander, M. H. Frere. In *Casebook on the Practical Use of Data from Experimental Watersheds*, Section 3.4, Environmental Monitoring Unesco, Paris, France, 1979.

302-10639-860-00

INCREASING THE BENEFICIAL USE OF STREAMFLOW

(*c*) R. R. Schoof, Hydraulic Engineer, USDA, Science and Education Administration, P.O. Box 400, Chickasha, Okla. 73018.

(*d*) Field studies and analysis; basic and applied research.

(*e*) Transmission loss from selected storm runoff events and base flow will be determined for streams with tandem gaging stations. The effect of dredging two channels on transmission losses will be investigated with before and after measurements. Water will be released from selected floodwater retarding reservoirs during the irrigation season to determine all losses between the reservoirs and irrigated fields. Water budget records will be collected at four floodwater retarding reservoirs and the effect of storage and extensive releases of water from reservoirs for irrigation on the reservoir onsite water loss will be determined. The purpose of the work is to evaluate transmission losses from flow in both natural and dredged channels with storm flows and with irrigation water releases, and to evaluate the impacts of using water stored in floodwater retarding reservoirs for supplemental irrigation in the Southern Plains.

(*g*) There are three primary factors which limit the use of water from SCS floodwater retarding structures for irrigation. (1) The initial cost of sprinkling equipment or land leveling and the high cost of labor. (2) The irrigable land usually lies some distance downstream. Thus much of the water may be lost during transmission down the channel. (3) Many of the permanent impoundments are small and would supply water for only very small projects. In 1977 only 486 acre-feet of water from floodwater retarding impoundments in Grady and Caddo Counties, Oklahoma, were used for irrigation. Peanuts was the principal crop irrigated. SCS impoundments within these two counties have potential permanent storage exceeding 13,000 acre-feet.

302-10640-820-00

EVALUATION OF ALLUVIAL AND TERRACE DEPOSITS FOR AQUIFER PERFORMANCE AND WATER SUPPLY CAPABILITY

(*b*) Cooperative with the Geology Department, Oklahoma State University, Stillwater, and the Oklahoma Water Resources Board, Oklahoma City.

(*c*) Dr. D. C. Kent, Geologist, Oklahoma State Univ., Stillwater, Oklahoma 74074, and J. W. Naney, Geologist, USDA, Science and Education Administration, P.O. Box 400, Chickasha, Oklahoma 73018.

(*d*) Field studies and analysis; basic and applied research.

(*e*) A USGS model of groundwater flow has been tested using data from the Tillman Terrace Deposits in Southwestern Oklahoma. The data included precipitation, streamflow, groundwater levels, and hydrogeologic properties of the Terrace Deposits. Preliminary estimates of groundwater conditions in these terrace deposits and in the alluvium of the Washita River, within the SEA-AR, study reach, have been made for 1993 using the model. The model results for the Tillman Terrace deposits were used by the Oklahoma Water Resources Board to establish groundwater rights for that subbasin as prescribed by Oklahoma Groundwater Law.

(*f*) Completed.

(*g*) A USGS model (Trescott-Pinder) has been calibrated with SEA-AR data on the Washita River and with OWRB data in the Tillman Terrace deposits and used to establish groundwater rights in the Tillman Terrace deposits, based upon model results to the year 1933.

(*h*) **Results of Computer Modeling of Alluvium and Terrace Deposits in Western Tillman County and along the Washita River, Southwestern Oklahoma for Water Supply Capability,** D. C. Kent, J. W. Naney, *Rept. Oklahoma Water Resources Board*, 52 pp., 1978. Memo Report.

302-11410-220-10

FLUME STUDIES OF TOTAL BED MATERIAL TRANSPORT

(*b*) Cooperative with the U.S. Army Corps of Engineers.

(*c*) J. C. Willis, Research Hydraulic Engineer, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.

(*d*) A theoretical and experimental investigation in a large-scaled flume of the mechanics and stochastic descriptions of bed-material discharge.

(*e*) The experimental investigation of the total sediment discharge, suspension distributions, and bed form characteristics for equilibrium, controlled flows up to 160 cfs will be used to test and/or modify relationships that have been developed for small flume studies. The main goal is to provide transport design criteria that may be applied to natural streams or rectification projects.

(*g*) The 250-ft outdoor test channel at the USDA Sedimentation Laboratory is being instrumented for the study. Data acquisition and analysis programs have been developed and tested for preliminary tests in a small test channel.

302-11411-300-10

ENERGY DISSIPATION IN ALLUVIAL CHANNELS

(*b*) Cooperative with the University of Mississippi and the U.S. Army Corps of Engineers.
(*c*) N. L. Coleman, Geologist, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Experimental; basic and applied research.
(*e*) Unsteady nonuniform flows are generated in a computer controlled laboratory flume for the conditions of (1) constant discharge, changing depth; (2) constant depth, changing discharges; (3) depth and discharge changing. The purpose is to attempt to derive a universal law for alluvial channel resistance in transient flows from the experimental results, using appropriate similitude parameters and a proper time-scaling factor.

302-11412-300-13

RELATIONS BETWEEN CHANNEL STABILITY AND VALLEY STRATIGRAPHY

(*b*) Cooperative with the University of Mississippi, Mississippi State University and the Vicksburg District Corp of Engineers.
(*c*) Dr. Earl H. Grissinger, Soil Scientist, and Dr. W. C. Little, Research Hydraulic Engineer, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Field and laboratory investigations, basic and applied research.
(*e*) By field investigation, determine the mode and magnitude of channel instability for each stratigraphic unit; determine the distribution of the several stratigraphic units; and, by laboratory and field determination, determine significant relations between failure mode and material properties.
(*f*) Two modes of bank failure have been observed; and each mode is associated with an individual stratigraphic unit. Block failure is characteristic of an old, highly weathered paleosol typified by polygonal structure. Massive failure, resulting from tension crack development parallel with the channel, is the characteristic failure mode for a younger, relatively unweathered paleosol. Radiocarbon ages of wood-rich stratigraphic units indicates a well defined marker bed for the time interval from 9,500 to 12,500 before present (BP); and a less frequently encountered marked bed dating from 4,500 to 6,000 BP. Most of the additional wood dates are younger than 2,500 BP.

U.S. DEPARTMENT OF AGRICULTURE, SCIENCE AND EDUCATION ADMINISTRATION, AGRICULTURAL RESEARCH

WESTERN REGION, 1333 Broadway, Suite 400, Oakland, Calif. 94612. H. C. Cox, Regional Administrator.

303-05209-840-00

DEVELOPMENT OF IMPROVED SURFACE IRRIGATION SYSTEMS

(*c*) A. S. Humpherys, Agr. Engr., USDA-SEA/AR, Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho 83341.
(*d*) Experimental, field investigations; applied research and development.
(*e*) Develop improved surface systems for the control and application of irrigation water. Devices, structures and techniques for manual, semiautomatic and automatic application of irrigation water will be developed to enable more efficient use of farm water supplies and reduce soil erosion and sedimentation. Structures and devices are tested in the laboratory and the field to determine their hydraulic characteristics and to evaluate the design, performance and adaptability to field conditions. Complete systems will be field tested to evaluate their water and labor requirements and ability to control erosion.
(*g*) Automatic, low pressure irrigation valves and the associated controls for surface irrigation have been developed in 4-, 6-, 8- and 10- inch sizes. These are used in gated pipe and buried lateral irrigation distribution systems. Commercial prototypes of the valves in 8- and 10-inch sizes are being field tested. The valves are controlled by battery-powered electronic timers and remotely by experimental microprocessor and commercial controllers. An electronic timer-controller for automatic furrow cutback irrigation has been developed. Preliminary head loss data for energy dissipating orifices in gated pipe have been obtained. A buried lateral multiset irrigation distribution system was effective in reducing runoff and erosion and in conserving irrigation water.
(*h*) **Controlling Sediment in Surface Runoff,** A. S. Humpherys, *Irrig. Age 12(1):22, 24,* Sept. 1977.
The Continuing Fight with Sediment, A. S. Humpherys, *Irrig. Age 12(3):73, 81,* Nov.-Dec. 1977.
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Float Valves Improve Pipeline Systems, A. S. Humpherys, *Irrig. Age 12(7):12, 15,* Apr. 1978.
Improving Farm Irrigation Systems by Automation, A. S. Humpherys, *Proc. Intl. Comm. on Irrig. and Drain., 10th Congress,* Athens, Greece, Question 35, R.5, pp. 35.90-35.98, May 1978.
Automating Furrow Irrigation Systems, A. S. Humpherys, *Irrig. Age 13(5):58, 59,* Feb. 1979.
Selecting a Buried Gravity Irrigation System, R. V. Worstell, *Trans. ASAE,* (in press).

303-07001-810-05

SIMULATION OF HYDROLOGIC SYSTEMS

(*b*) Cooperative with Colorado State University.
(*c*) Dr. David A. Woolhiser, Research Hydraulic Engineer, USDA-SEA, Engineering Research Center, CSU Foothills Campus, Fort Collins, Colo. 80523.
(*d*) Theoretical and experimental; basic and applied.
(*e*) Develop procedures for numerically simulating the surface runoff hydrograph of small watersheds and objective techniques for transforming complex watersheds into simple combinations of overland flow planes and channels for numerical solution.
(*g*) Data from the CSU-SEA Experimental Rainfall-Runoff Facility were used in a study of the effects of spatial variability on watershed response. A method was developed to replace complex roughness patterns by an equivalent uniform surface by matching equilibrium surface storage. Maximum likelihood methods were used to directly estimate Fourier series coefficients describing the seasonal variability of parameters for a stochastic daily precipitation model. A comprehensive, parameter-efficient model for infiltration has been developed from simplifying assumptions on basic soil water physics. The model uses two parameters plus the soil water content (a variable), and responds to all practical patterns of rainfall input. The effects of spatial variability of infiltration parameters were examined using Monte Carlo simulation.
(*h*) **Control of Nonpoint Water Pollution from Agriculture: Some Concepts,** M. H. Frere, D. A. Woolhiser, J. H. Caro, B. A. Stewart, W. H. Wischmeier, *J. Soil and Water Conservation* **32,** 6, pp. 260-264, Nov.-Dec. 1977.
Probable Effect of Summer Weather Modification on Runoff, C. L. Hansen, D. A. Woolhiser, *J. IR Division, Proc. of ASCE* **104,** IR1, p. 1-11, Mar. 1978.
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Discussion of **Infiltration Formula Based on SCS Curve Number, by Gert Atron, Arthur C. Miller, Jr., David F. Lakatos,** R. E. Smith, K. G. Eggert, (*ASCE Proc. Paper No. 13427,* Dec. 1977), *J. IR Division, Proc. of ASCE, No. IR4,* Dec. pp. 464-466, 1978.

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A Parameter-Efficient Hydrologic Infiltration Model, R. E. Smith, J.-Y. Parlange, *Water Resources Research* **14**, 3, June, pp. 533-538, 1978.

Effects of Surface Roughness and Its Spatial Distribution on Runoff Hydrographs, Y.-H. Wu, V. Yevjevich, D. A. Woolhiser, *Colorado State Univ. Hydrology Paper No. 96*, 47 pp., Oct. 1978.

303-09315-810-00

INFLUENCE OF CLIMATIC, BIOLOGIC, AND PHYSICAL FACTORS ON RANGELAND WATERSHED HYDROLOGY

(*b*) Soil Conservation Service and Bureau of Land Management.

(*c*) L. M. Cox, Hydrologist, Northwest Watershed Research Center, 1175 South Orchard, Patti Plaza, Suite 16, Boise, Idaho 83705.

(*d*) Experimental, applied research.

(*e*) Develop, test, and apply methods for measuring and predicting snow water distribution for continuous and discontinuous (drift) snowpack areas; test and improve snowmelt computation procedures for long-term and short-term (approaching real time) forecast periods. Provide precipitation inputs compatible with watershed modeling requirements. Develop and test watershed models for runoff prediction and stream channel flow conveyance consistent with needs for predicting environmental impact of rangeland management on water quality and supply.

(*g*) Instrumentation for sensing snow water equivalent and hydrometeorological parameters utilized in the SNOTEL system have been evaluated. Improved water supply forecasting procedures are being tested. A snow fence installed at a drift site is being evaluated for increasing the snow water supply. Increased flow in a spring fed from the drift area has been observed. Progress is being made on testing a water quality model applicable to predicting water temperature, dissoved oxygen, and BOD in rangeland streams. A stochastic rainfall-runoff model was used to determine the effect of a weather modification program on summer runoff in western South Dakota. The Wyoming shield precipitation gage is very effective in windy rangeland sites.

(*h*) **Probable Effect of Summer Weather Modification on Runoff,** C. L. Hanson, D. A. Woolhiser, *J. Irrig. and Drainage Div., ASAE, 104(IR1)*, pp. 1-11, 1978.

A Method for Determining Sensible Heat Transfer to Late-Lying Snowdrifts, L. M. Cox, J. F. Zuzel, *Proc. 44th Ann. Mtg., Wstern Snow Conf.*, Apr. 20-22, pp. 23-28, 1976.

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303-09316-810-00

INFLUENCE OF BIOLOGIC AND SOIL FACTORS ON RANGELAND WATERSHED HYDROLOGY

(*b*) Bureau of Land Management.

(*c*) D. L. Brakensiek, Hydr. Engr., Northwest Watershed Research Center, 1175 South Orchard, Patti Plaza, Suite 116, Boise, Idaho 83705.

(*d*) Experimental, applied research.

(*e*) Investigate the accretion and disposition of soil water under rangeland conditions by infiltration and by soil evaporation and vegetation transpiration; determine the influences of rangeland soil and vegetation management on runoff water quality parameters; and develop process models for infiltration, soil water movement, vegetation growth and production, evapotranspiration, and streamflow water quality.

(*g*) Parameters of the Green and Ampt infiltration equations are being estimated from soil moisture characteristics. The USDAHL-74 watershed model was tested on a small rangeland watershed. Soil water changes were adequately modeled; however, the small amounts of runoff were modeled less accurately. A baseline value of 30 fecal coliform conc/100 ml has been established for open range streamflow. The reduction of streamflow fecal coliform by development of upland water sources has been quantified.

(*h*) **Effect of Grazing Intensity and Range Condition on Hydrology of Western South Dakota Ranges,** C. L. Hanson, A. R. Kuhlman, J. K. Lewis, *So. Dakota Agr. Exp. Bull. 647*, 54 pp., 1978.

Bacterial Variations in Streams from a Southwest Idaho Rangeland Watershed, G. R. Stephenson, L. V. Street, *J. Environ. Quality, 7(1)*, pp. 150-156, 1978.

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303-09318-830-00

EFFECT OF RUNOFF, PRECIPITATION, CLIMATE, SOIL, VEGETATION, LAND USE AND LAND FORM ON SEDIMENT YIELD

(*b*) Bureau of Land Management.

(*c*) C. W. Johnson, Hydraulic Engineer, Northwest Watershed Research Center, 1175 South Orchard, Suite 116, Patti Plaza, Boise, Idaho 83705.

(*d*) Experimental, applied research.

(*e*) Determine bedload and suspended sediment characteristics and transport rates in rangeland watershed streams under a wide range of conditions. Determine relationships between erosion, sediment yield, runoff, rainfall, snowmelt, cover, land use, and topographic and physiographic features. Evaluate factors in the Universal Soil Loss Equation applicable to rangelands. Improve sediment sampling equipment and methods for debris-laden streamflow. Study the effectiveness of irrigation systems in reducing downstream sediment loads.

(*g*) Helley-Smith bedload samplers were used to determine sediment particle-size and transport rates under a wide range in streamflow on the Reynolds Creek Watershed. Relationships between watershed sediment yield and runoff were determined for some areas. Sediment loads downstream from irrigated areas were greatly reduced by diverting natural streamflow, which caused deposition on irrigated lands. Five runoff and sediment measuring stations were constructed and instrumented near Boise, Idaho, to study watersheds under a rotation grazing system.

(*h*) **Helley-Smith Bedload Samplers,** C. W. Johnson, R. L. Engleman, J. P. Smith, C. L. Hanson, *Proc. ASCE, J. Hydraul. Div., 103(HY10):1217-1221*, 1977.

Sediment Characteristics and Transport from Northwest Rangeland Watersheds, C. W. Johnson, J. P. Smith, *Trans. of ASAE, 21(6):1157-1162; 1168*, 1978.

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303-09320-830-00

CAUSATIVE FACTORS AND SYSTEMS FOR CONTROL OF EROSION IN THE PACIFIC NORTHWEST DRYLAND GRAIN GROWING REGION

(*b*) Cooperative with Washington State University Agricultural Experiment Station, University of Idaho Agricultural Experiment Station and Soil Conservation Service.

(c) D. K. McCool and R. I. Papendick, USDA, SEA-AR, 219 Smith Agricultural Engineering Building, Washington State Unviersity, Pullman, Wash. 99164.
(d) Experimental, and field investigation; basic, applied, and developmental research.
(e) Use field studies to determine the quantitative effects of climatic influence, physiographic features, soil physical conditions, and agricultural land treatment on water-caused soil erosion. Develop from these data empirical models for short-term use in predicting soil loss on Northwest soils. Develop and test, in laboratory and field, combined hydrologic/erosion-sedimentation models to determine their usefulness in assessing the effect on soil erosion and water quality of proposed cultural treatments and mechanical systems.
(g) A first-generation adaptation of the Wischmeier-Smith or Universal Soil Loss Equation has been developed from field soil loss data. The adaptation includes slope length and steepness relationships different from those used in the midwest as well as a rainfall and runoff factor that includes the effects of runoff from snowmelt and from rain on thawing soil. The adapted equation is being used by the Soil Conservation Service in Idaho, Oregon, and Washington. Research to improve the relationships is continuing. A study of Pullman, Washington and Corvallis, Oregon raindrop size and intensity data for developing a low intensity rainfall simulator was completed. Even though the Northwest rainfall intensities are much lower, the drop size/intensity relationships are quite similar to those developed by Laws and Parsons in 1941. However, the kinetic energy/intensity relationships were somewhat different, apparently due to a difference in the skew between the Northwest and the Washington, D.C. drop size distribution.
(h) **Effect of Slope Length and Steepness on Rill Erosion in the Pacific Northwest Wheat Region,** D. K. McCool, R. I. Papendick. Presented *1977 Summer Meeting, ASAE.* Copy of paper can be obtained from first author.
Raindrop Characteristics in the Pacific Northwest, D. K. McCool, M. J. Robinette, J. T. King, M. Molnau, J. L. Young Presented *1979 Summer Meeting, ASAE.* Copy of paper can be obtained from first author.

303-10623-810-00

RUNOFF QUANTITY AND QUALITY FROM PASTURE AND CROPLAND WATERSHEDS IN THE PALOUSE REGION OF WASHINGTON AND IDAHO

(b) Partially supported by EPA and cooperative with the Agricultural Experiment Stations of Washington State University and the University of Idaho.
(c) K. E. Saxton or D. K. McCool, USDA, SEA-AR, Smith Agricultural Engineering, Washington State University, Pullman, Wash. 99164.
(d) Experimental and field investigation; basic and applied research.
(e) Several small agricultural watersheds are being studied to determine the hydrology, sedimentation, and water quality as related to agricultural land management. Runoff from a well-managed grazed watershed and an adjacent ungrazed check watershed is being studied for sediment, chemical, and biological characteristics. Similar data from two meadow watersheds will also determine water quality from ungrazed areas. Runoff, sedimentation, and chemical quality are being determined from three cropland watersheds approximately 2, 9, and 27 square miles in size. Crops are primarily winter wheat in rotation with spring wheat, barley, and peas. Tillage ranges from conventional plow-disk to heavy stubble mulch.
(g) Preliminary results from the fertilized pastured grass watersheds show low concentrations of sediment and chemicals. Bacteria concentrations vary considerably annually and within runoff events depending upon the presence of cattle, temperatures, and overland flow rates.
(h) **Survival of Fecal Coliforms and Fecal Streptococci on a Pacific Northwest Pasture Watershed,** M. D. Jawson, L. F. Elliot, D. F. Fortier, K. E. Saxton. Presented *Amer. Society of Agronomist's Ann. Mtg.,* Chicago, Ill., Dec. 1978. Copies available from Mr. Jawson, USDA-SEA-AR, 215 Johnson Hall, Washington State University, Pullman, Wash. 99164.

303-10624-870-00

NONPOINT POLLUTION CONTROL FOR RANGELAND WINTER LIVESTOCK OPERATIONS

(b) Cooperative with University of Idaho Agricultural Experiment Station.
(c) G. R. Stephenson, Geologist, USDA, SEA-AR, 1175 South Orchard, Patti Plaza, Suite 116, Boise, Idaho 83705.
(d) Experimental, applied research.
(e) Evaluate alternative management practices, and develop guidelines, for the control of waterborne pollutants from cow-calf wintering operations. Six plots have been established on a private cattle ranch in Owyhee County, Idaho. The plots are being used for three treatments with two replications of the cattle stocking rates: (1) no cattle, (2) 10 head/hectare, and (3) 40 head/hectare. The actual number of mature cattle wintered on the plots from January 13 through April 2, 1978, was 0, 0, 6, 8, 26, and 29 head, respectively. Approximately 60 cows calved during this period. Six additional research plots have been established. The plots are on the same ranch and involve three ground cover treatments (hay crop) with two replications. Cattle will be placed on all plots during the 1978-79 winter.
(g) Samples of runoff water were taken during three irrigation events and a rain event on April 25 and 26, which added 5.3 cm of water. The effects of this rainfall event were included with the first irrigation event. Nutrient levels from first irrigation showed ratios of 1:2:5.5 for the no cattle, 10 head/hectare, and 40 head/hectare fields, respectively. Fecal coliform bacteria counts averaged zero for the no cattle field, 3972 counts/100 ml for the 10 head/ha field and 9449 counts/100 ml for the 40 head/ha field. Data processing has not been completed for the last two irrigations.
(h) **Evaluation of Rangeland Management Practices for Improved Water Quality,** G. R. Stephenson, J. E. Dixon. Presented *1979 ASAE Winter Mtg.,* New Orleans, La.

303-10625-810-00

DEVELOP METHODS TO PREDICT PRECIPITATION AND RUNOFF FOR BETTER USE AND PROTECTION OF SOIL AND WATER RESOURCES OF SOUTHWESTERN RANGELANDS

(c) Herbert B. Osborn, Supr. Hydrologic Engr., USDA, SEA-AR, Southwest Rangeland Watershed Research Center, Tucson, Ariz. 85705.
(d) Experimental project based on rainfall and runoff data from semi-arid rangelands in Arizona and New Mexico.
(e) Determine statistics of convective rainfall and runoff on experimental watersheds. Develop methods to estimate rainfall patterns and runoff in ephemeral stream channels. Develop models to simulate hydrologic responses of watersheds to predict changes from rangeland restoration or management practices.
(g) Previously developed rainfall occurrence and depth-area models for Arizona and New Mexico were combined into one functional simulation model. The models were developed from SEA-AR and NWS rainfall and climatological data. Analysis of rainfall records from dense USDA, SEA-AR raingage networks in Arizona and New Mexico indicated that relationships published by NWS (NOAA Atlas 2) for estimating peak discharges from ungaged basins should be modified in regions where runoff is dominated by airmass thunderstorm rainfall. Data analysis from these dense networks also indicated that 100-yr. storm rainfall did not increase with elevation and, therefore, indicated that flood peak estimates for small mountain watersheds could be based on valley rainfall records. Results of a partial area response analysis of watershed runoff indicated that, on the average, 40 to 60 percent of the watershed areas were contributing runoff at the watershed outlet. A continuous simulation model was

developed to evaluate nonpoint source pollution for the field scale. This model uses as the hydrologic input either the SCS curve number system or the Green and Ampt infiltration relation. Two procedures were developed to estimate transmission losses. One procedure uses geomorphic relations of stream order, drainage area, and alluvium volume to estimate loss potential. The other procedure uses a SCS curve number hydrologic model for estimating losses in emphmeral streams. The geomorphic approach appears more practical because of the simplicity of measuring input variables. A parameter using geomorphic variables was developed to predict hydrograph characteristics for semiarid basins of the Southwest. This parameter expressing basin shape and size proved to be as accurate as the other existing prediction equations tested, and was simpler and faster to derive.

(*h*) **Effects of Rainfall Intensity on Runoff Curve Numbers,** R. H. Hawkins, *Hydrology and Water Resources of Arizona and the Southwest, Proc. AAS-AWRA, 8:53-64*, 1978.

Effectiveness of Sealing Southeastern Arizona Stock Ponds With Soda Ash, H. B. Osborn, J. R. Simanton, R. B. Koehler, *Hydrology and Water Resources of Arizona and the Southwest, Proc. AAS-AWRA, 8:73-78*, 1978.

Geomorphic Parameters Predict Hydrograph Characteristics in the Southwest, J. B. Murphey, D. E. Wallace, L. J. Lane, *Water Res. Bull., AWRA 13(1):25-38*, 1977.

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Simplification of Watershed Geometry Affecting Simulation of Surface Runoff, L. J. Lane, D. A. Woolhiser, *J. Hydrol., 35:173-190*, 1977.

Simulation of Summer Runoff Occurrence in Arizona and New Mexico, H. B. Osborn, D. R. Davis, *Hydrology and Water Resources in Arizona and the Southwest, Proc. AAS-AWRA, 7:153-163*, 1977.

303-10626-810-00

SEDIMENT SOURCES, TRANSPORT AND PROPERTIES IN SEMI-ARID WATERSHEDS

(*c*) Kenneth G. Renard, Supr. Hydraulic Engr., USDA-SEA-AR, Southwest Rangeland Watershed Research Center, Tucson, Ariz. 85705.

(*d*) Experimental project to improve water erosion predicting and control on semi-arid rangelands.

(*e*) Develop improved methods to predict water and erosion and control to preserve and increase productivity of land and water resources.

(*g*) Partial area runoff analysis was used to infer sediment source areas. This analysis included three modeling procedures: a regression model, a lumped linear model, and a distributed kinematic cascade model. A sediment yield model derived from a complex erosion simulation model was tested using data from a small watershed in southeastern Arizona. Results suggest that the model is comparable to the Universal Soil Loss Equation. Rainfall simulator tests indicated that erosion rates from a semiarid rangeland might be transport limited because more soil was detached by raindrop impact than was transported in overland flow. Sediment yields from small semiarid watersheds were several times greater from gullied than from ungullied watersheds and as much as 10 times greater from brush-covered than grass-covered watersheds. Sediment yields from a brush to grass converted semiarid watershed were reduced 90 percent after conversion.

(*h*) **A Sediment Yield Equation from an Erosion Simulation Model,** E. D. Shirley, L. J. Lane, *Hydrology and Water Resources in Arizona and the Southwest, Proc. AAS-AWRA, 8:90-96*, 1978.

Effects of Brush to Grass Conversion on the Hydrology and Erosion of a Semiarid Southwestern Rangeland Watershed, J. R. Simanton, H. B. Osborn, K. G. Renard, *Hydrology and Water Resources in Arizona and the Southwest, Proc. AAS-AWRA, 7:249-256*, 1977.

Erosion Research and Mathematical Modeling, K. G. Renard. In *Erosion: Research Techniques, Erodibility, and Sediment Delivery*, T. J. Toy, editor GEO Books, Norwich, England, p. 31-44, 1977.

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303-10627-810-00

INCREASED WATER-USE EFFICIENCY IN SEMI-ARID REGIONS FOR GREATER AND STABLER FORAGE

(*c*) Robert M. Dixon, Soil Scientist, USDA, SEA-AR, Southwest Rangeland Watershed Research Center, Tucson, Ariz. 85705.

(*d*) Experimental project to determine principles and practices for controlling point infiltration and onsite runoff.

(*e*) Develop principle and practices for controlling infiltration and runoff leading to improved forage production.

(*g*) The air-earth interface concept for rainwater infiltration control in cropland was found to apply equally well to rangelands. This concept states that the microroughness and macroporosity of the soil surface control infiltration with the rough macroporous surface absorbing most of the rainwater from intense storms and the smooth microporous surface shedding most of this water. Managing rangelands for high infiltration rates can greatly improve forage production, enhance wildlife habitats, and control nonpoint-source pollution. A new tillage implement, the land imprinter, has been developed for applying the air-earth interface concept. This implement is designed to manipulate the microroughness and macroporosity of the soil surface. The land imprinter has several intrinsic advantages relative to conventional tillage implements, including its ability to (1) safely increase depression storage by forming relatively stable closed angular pockets without inverting the soil surface, (2) increase rather than decrease effective surface mulch by concentrating all above-ground plant

material at the soil surface, and (3) indent and emboss the soil surface with geometric patterns that give better control over infiltration, runoff, and erosion. Effective control of rainwater infiltration can greatly increase and stabilize the biomass productivity of many agricultural land areas. Water harvesting systems using parafix wax and asphalt-fiberglass catchment aprons were used to increase forage yield and available livestock drinking water.

(*h*) **A Land Imprinter for Revegetation of Barren Land Areas Through Infiltration Control,** R. M. Dixon, J. R. Simanton, *Hydrology and Water Resources of Arizona and the Southwest, Proc. AAS-AWRA, 7:79-88*, 1977.

Air-Earth Interface Concept for Wide-Range Control of Infiltration, R. M. Dixon, *Ann. Mtg. ASAE*, Raleigh, N.C., *Paper No. 70-2062*, 33 pp., 1977.

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303-11413-840-00

FIELD TESTING LOW ENERGY, LOW LABOR, AND EFFICIENT IRRIGATION SYSTEMS

(*c*) A. S. Humphreys, Agricultural Engineer, USDA-SEA/AR, Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho 83341.

(*d*) Experimental, field investigations; applied research and development.

(*e*) A complete automated research/demonstration irrigation system with three different subsystems was installed in a farmer cooperator's 63-acre field during 1977. The subsystems include two automatic cutback gated pipe systems, a buried lateral multiset system and two check areas irrigated conventionally with siphon tubes from a lined ditch. Different types of automated irrigation valves, timer-controllers, soil moisture sensors and other equipment will be evaluated under field conditions. The objectives are to obtain data on design criteria, installation and operating procedures, costs, energy use, operating labor, erosion control, and irrigation efficiency of field scale, automated, energy conserving surface irrigation systems.

(*g*) Data obtained to date are preliminary. Total seasonal water applied during 1977 and 1978 was 32 percent and 58 percent less with the automated subsystems than was applied on the check areas using the farmer's normal irrigation practices.

303-11414-840-00

THE EFFECTS OF IRRIGATION PRACTICES ON SALT OUTFLOW AND DRAINAGE WATER QUALITY FROM NEW AND OLD IRRIGATED LANDS

(*c*) David L. Carter, Supervisory Soil Scientist, Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho 83341.

(*d*) Experimental field investigation; basic and applied research.

(*e*) Specific irrigation treatments were applied to land not previously irrigated and to land irrigated for 70 years. The quantity of salt in the soil was measured by soil sampling before and after each irrigation season. The salt outflow was determined by difference, accounting for the salt in the irrigation water. The study was conducted for two years. The purpose of the research was to measure the quantity of residual soluble salts expected in outflows of subsurface drainage water as new lands are irrigated, and to determine the quantity of water that must pass through the soil to remove residual salt. The information provided can be used to predict environmental impact of irrigating new land and the effects of irrigation on the salt outflow in subsurface drainage water.

(*f*) Completed.

(*g*) The total quantity of residual salt removed from previously nonirrigated soil, 5 m deep, was 70 metric tons/ha. About 30 metric tons/ha was removed by the first 14 cm of leachate. After 30 cm of water/m depth of soil had passed from the soil as leachate, regardless of the number of seasons required for that amount of leaching, residual salts were essentially removed. Subsequent salt outflow from the soil was directly related to the quantity of water leaching through the soil, indicating that more minerals dissolved with more leaching.

(*h*) **Salt Outflows from New and Old Irrigated Lands,** D. L. Carter, C. W. Robbins, *Soil Sci. Soc. Amer. J. 42:632*, 1978.

303-11415-830-00

CONTROLLING EROSION AND SEDIMENT LOSS FROM IRRIGATED LANDS WITH A BURIED PIPE TAILWATER CONTROL SYSTEM

(*c*) D. L. Carter, Supervisory Soil Scientist, Snake River Conservation Research Center, Route 1, Kimberly, Idaho 83341.

(*d*) Experimental field investigation; applied research.

(*e*) Buried pipe with inlets at intervals replaces the conventional tailwater ditch along the bottom of irrigated fields. Small earthen checks are formed immediately on the downslope side of each pipe inlet to form small sediment basins. The elevation of the inlet to the buried pipe controls the water depth and the depth of sedimentation in the basins. Fields that have been severely eroded along the lower ends can be restored to natural slope.

(*g*) The buried pipe tailwater control system removes about 80 percent of the sediment eroding from furrows. As the sediment settles and fills the small sediment basins, erosion at the lower ends of fields is greatly reduced. The new system allows cultivation and weed control practices on parts of fields while other parts are being irrigated because the tailwater is in the buried pipe and the lower end of the field is not wet during all water sets as is the case with conventional irrigation. The buried pipe tailwater control system is a new erosion control alternative for irrigated land.

303-11416-810-34

SOIL-VEGETATION-HYDROLOGIC STUDIES–MONTANA

(*b*) U.S. Department of Interior, Bureau of Land Management.

(*c*) Earl L. Neff, Hydraulic Engineer, Northern Plains Soil and Water Research Center, P.O. Box 1109, Sidney, Mont. 59270.

(*d*) Experimental, applied research.

(*e*) The objective of this project is to evaluate the effects of contour furrowing saline-sodic rangelands soils on vegetation response, surface runoff, erosion, and soil water recharge. The rangelands are in southeastern Montana in the Pierre Shale plains and Badlands resource area. Sixteen 0.8-hectare watersheds were established in 1967. Eight were contour furrowed and eight were left in the natural range condition. Each watershed was instrumented with recording raingages, a water measuring flume with continuous water level recorder, and soil water measuring access tubes. Ten watersheds were instrumented with automatic, pumping type sediment samplers. Vegetation yield is measured on each watershed by annual random sampling.

(*f*) Scheduled for termination in FY 1981.

(*g*) Annual vegetation yields average 2-3 times more from contour furrowed than from non-furrowed watersheds. Well-constructed contour furrows have an effective water storage life of about 25 years. Contour furrows increase overwinter soil water recharge about 160 percent which accounts for about 75 percent of the variance in vegeta-

tion yield the following growing season. Contour furrows significantly reduce surface runoff.

(*h*) **Improving Precipitation-Use Efficiency on Rangeland by Surface Modification,** J. R. Wight, F. H. Siddoway, *J. Soil and Water Conserv. 27(4):170-174*, 1972.

Water Storage Capacity of Contour Furrows in Montana, E. L. Neff, *J. Range Manage. 26(4):298-301*, 1973.

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Runoff and Reservoir Quality for Livestock Use in Southeastern Montana, R. J. Soiseth, *J. Range Manage. 28(5):344-348*, 1975.

Snow Management on Eastern Montana Rangelands, J. R. Wight, E. L. Neff, F. H. Siddoway. In *Snow Management on the Great Plains Symposium, Great Plains Agric. Council Pub. 73*, Univ. of Nebraska, Lincoln, p. 138-143, 1975.

Land Surface Modifications and Their Effects on Range and Forest Watersheds, J. R. Wight, In *Proc. 5th Workshop of the United States/Australia Rangelands Panel: Watershed Management on Range and Forest Lands*, Utah State University, Logan, p. 165-174, 1976.

Overwinter Soil Water Recharge and Herbage Production as Influenced by Contour Furrowing on Eastern Montana Rangelands, E. L. Neff, J. R. Wight, *J. Range Manage. 30(3):193-195*, 1977.

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Vegetation Response to Contour Furrowing, J. R. Wight, E. L. Neff, R. J. Soiseth, *J. Range Manage. 31(2):97-101*, 1978.

Maximizing Forage Production on Fine-Textured, Sodic-Affected Range Sites in the Northern Great Plains, J. R. Wight, E. L. Neff, R. J. Soiseth, *Rangeman's J. 5(2):42-44*, 1978.

303-11417-840-88

ON FARM CONVENTIONAL AND POTENTIAL IRRIGATION EFFICIENCY

(*b*) Cooperative with the Imperial Irrigation District, El Centro, Calif.

(*c*) L. F. Hermsmeier, Agric. Eng., Imperial Valley Conservation Research Center, 4151 Highway 86, Brawley, Calif. 92227.

(*d*) Field investigation; applied research.

(*e*) Present irrigation practices on 9 Imperial Valley fields are being measured and analyzed. The water entering the field, the amount stored for crop use, the surface runoff and the drain flow are measured. Computed consumptive use is compared with irrigation amounts. Uniformity of application and leaching amounts are determined for selected irrigations. The purpose is to develop improved methods to increase surface irrigation efficiencies. At present the 500,000 acres of irrigated land in the Imperial Valley receive about 2,800,000 acre-feet of irrigation water per year and of this amount approximately 1,000,000 acre-feet or 36 percent flows to the Salton Sea. The low efficiency is generally due to the poor operation and management of farm irrigation water.

(*g*) Measured irrigation efficiencies in farm irrigated fields ranged from 45 to 90 percent.

303-11418-840-00

IRRIGATION ADVANCE AND RECESSION MODELING

(*b*) Cooperative with the University of California, Davis.

(*c*) J. A. Replogle, U.S. Water Conservation Laboratory, USDA, SEA-AR, 4331 East Broadway, Phoenix, Ariz. 85040.

(*d*) Theoretical.

(*e*) Developing irrigation advance and recession computer models that can accommodate various combinations of flow-application rates and times; hypothetical field conditions, including infiltration, field roughness, slope, length, furrow, and border shapes; and tailwater runoff. The purpose is to develop means to optimize irrigation efficiencies on sloping fields.

(*g*) The advance and recession modeling has been developed on three levels of mathematical endeavor. A complete hydrodynmaic model is used as the accuracy standard for the lesser models. The most suitable compromise model, the zero-inertia model, ignores inertial terms in the basic equations, but copies the complete model to within 1 percent. Work on suitable furrow modeling continues.

(*h*) **Hydrodynamics of Border Irrigation–Complete Model,** N. D. Katopodes, T. Strelkoff, *J. Irrig. and Drain. Div., 103:309-324, ASCE*, 1977.

Border-Irrigation Hydraulics with Zero Inertia, T. Strelkoff, N. D. Katopodes, *J. Irrig. and Drain. Div.,103:325-342, ASCE*, 1977.

303-11419-700-00

PREDICTING HYDRAULIC CHARACTERISTICS OF CRITICAL-DEPTH FLUMES OF SIMPLE AND COMPLEX CROSS-SECTIONAL SHAPES

(*c*) J. A. Replogle, Research Hydraulic Engineer, U.S. Water Conservation Laboratory, USDA, SEA-AR, 4331 East Broadway, Phoenix, Ariz. 85040.

(*d*) Theoretical; applied research, field studies.

(*e*) Develop and apply mathematical modeling techniques for predicting the stage-discharge relations of flumes designed for irrigation and streamflow measurements. The mathematical model is being used to evaluate dimensional relationships and the effects of dimensional deviations on discharge ratings. Standard sizes and shapes for irrigation canals are being developed.

(*g*) Mathematical model has been completed. Laboratory verification on several sizes and shapes has been completed. A broad-crested-weir style has been analytically studied and selected as the best shape for irrigation use, from the standpoint of low cost and accuracy.

(*h*) **Critical-Flow Flumes with Complex Cross-Section,** J. A. Replogle. In *Irrigation and Drainage in an Age of Competition for Resources*, Irrig. and Drain. Div., Amer. Soc. of Civil Eng., pp. 366-388, 1975.

Compensating for Construction Errors in Critical-Flow Flumes and Broad Crested Weirs, J. A. Replogle. In *Flow Measurement in Open Channels and Closed Conduits I, National Bureau of Standards, Spec. Pub. 484*, pp. 201-218, 1977.

Flumes and Broadcrested Weirs–Mathematical Modeling and Laboratory Ratings, J. A. Replogle. In *Flow Measurement of Fluids* (H. H. Dijstelbergen and E. A. Spencer, Editors). North Holland Pub. Co., Amsterdam, New York, Oxford, pp. 321-328, 1978.

303-11420-820-65

GROUNDWATER RECHARGE FOR CONJUNCTIVE MANAGEMENT OF SURFACE AND GROUNDWATER STORAGE

(*b*) Cooperative with the City and County of Fresno, Calif.

(*c*) W. C. Bianchi, Soil Scientist, Water Management Research, 4816 E. Shields Ave., Fresno, Calif. 93726.

(*d*) Experimental, field investigations, applied research and development.

(*e*) To describe recharge site selection procedures, develop construction techniques, improve operation and maintenance of facilities, and provide new methods for efficiently and economically using the storage capabilities of groundwater reservoirs for storage of high quality water.

(*g*) Conducting studies on (1) water movement through stratified alluvium to the water table as related to the building and dissipation of groundwater storage, (2) the protection and regeneration of the percolation capacity of surface soils and exposed aquifers clogged with suspended matter found in surface waters, (3) design and construction of facilities (wells, shafts, collectors, filter systems) to by-pass perching layers and so maximize the recharge per unit of occupied area, (4) control of water quality con-

sistent with groundwater use, and (5) the physical-chemical interactions that can control surface soil, layer, and aquifer permeability.

(*h*) **Environmental Aspects of Water Spreading for Groundwater Recharge,** H. I. Nightingale, W. C. Bianchi, *USDA Technical Bulletin No. 1568*, pp. 1-31, Oct. 1977.

Artificial Groundwater Recharge, W. C. Bianchi, Chapter 6, in *State of the Art, Irrigation, Drainage and Flood Control 1:331-355*, 1978. Publication of International Commission on Irrigation and Drainage. (Reprints available on request.)

A Case History to Evaluate the Performance of Water-Spreading Projects, W. C. Bianchi, H. I. Nightingale, R. L. McCormick, *J. Amer. Water Works Assoc. 70(3):176-180*, 1978.

Fresno, Calif., Subsurface Drain Collector–Deep Well Recharge System. W. C. Bianchi, H. I. Nightingale, R. L. McCormick, *J. Amer. Water Works Assoc. 70(8):427-435*, 1978.

Geological Relationships to Groundwater Recharge in the San Joaquin Valley, D. Cehrs, in *Groundwater Symposium, Recharge and Regulation*, Univ. of Calif. Coop. Extension, Fresno, Calif., 7 p., 1978.

303-11421-820-65

AGRICULTURAL AND URBAN GROUNDWATER QUALITY MANAGEMENT

(*b*) Cooperative with the City and County of Fresno, Calif.
(*c*) H. I. Nightingale, Soil Scientist, Water Management Research, 4816 E. Shields Ave., Fresno, Calif. 93726.
(*d*) Experimental, field investigations, applied research and development.
(*e*) To preserve the quality of groundwater, evaluate sources pollutants and develop techniques to control pollutants entry and residence in the groundwater body.
(*g*) Field studies analytical methods, and data interpretation techniques will be developed and evaluated to define the geological and soil-plant-water relationships that control the entry and subsurface movement of agricultural and urban-generated groundwater pollutants. These observations will be related to management of pollutant entry through altered cultural practices with regard to cropping pattern, irrigation and fertilizer application techniques, and on-farm water, fertilizer, and energy conservation. Develop criteria for the use of interception and spot dilution-recharge technology to prevent and/or minimize the source area inputs. Research will be conducted at selected recharge sites, on cooperator waste disposal facilities, and on irrigated field plots of various soils and subsurface geology.
(*h*) **Groundwater Recharge Rates from Thermometry,** H. I. Nightingale, *Groundwater 13(4):340-344*, 1975.

Lead, Zinc, and Copper in Soils of Urban Storm-Runoff Retention Basins, H. I. Nightingale, *J. Amer. Water Works Assoc. 67(8):443-446*, 1975.

Groundwater Chemical Quality Management by Artificial Recharge, H. I. Nightingale, W. C. Bianchi, *Groundwater 15(1):15-21*, Jan.-Feb. 1977.

Groundwater Turbidity Resulting from Artificial Recharge, H. I. Nightingale, W. C. Bianchi, *Groundwater 15(2):146-155*, Mar.-Apr. 1977.

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U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION, Ogden, Utah 84401. Roger R. Bay, Station Director.

304-06969-810-00

SNOWPACK HYDROLOGY

(*c*) Mr. Harold F. Haupt, Project Leader, Forestry Sciences Laboratory, 1221 South Main, Moscow, Idaho 83843.
(*d*) Field investigation, basic and applied research.
(*e*) Snowpack is being studied in northern Idaho for the applied objective of regulating yield and timing of streamflow. The particular research reported here pertains to improved instrumentation for measuring winter precipitation and estimated potential water yield as affected by slope exposure and early site recovery.
(*f*) Completed.
(*g*) The hydrologic response of small clearcuts on north and south slopes in northern Idaho was investigated. On north slope, substantial gains (27 to 35 cm) in potential water yield per year accrued from removal of transpiring surfaces associated with plant cover, elimination of snow interception by a closed-canopied forest, perhaps some airborne movement of snow from the south (windward) to north (lee) slope, and slow reoccupation of the soil mantle by invading plant species. In contrast, on south slope there appeared to be no long-term gain in potential water yield resultant from timber cutting. Small differences in estimated yield between forest and small clearcut were evident in some years; in other years, none. Site factors with compensating effect were the cause. In the south-slope forest, water losses from interception were light because of the open-canopied structure of the timber, whereas in the small clearcut, water gains from reduced transpiration were more than used up by invading shrub species. We conclude that managing for increased water yield may be a valid consideration in the decision to log north but not south slopes similar to those studied.

A simple technique has been found to install soil moisture access tubes in stony or bouldery forest soils with a minimum of site disturbance. The hole for the access tube is made by driving a pointed, machine-tooled driving rod to the depth required with a specially constructed 15 kg king tube hammer. Under good soil conditions, 14 to 16 access tubes can be installed in a day, but when the soil is excessively bouldery, the number is reduced to five to seven. This method has the advantage of requiring substantially less capital outlay, causing less disturbance to surroundings and providing easier access to remote study areas than methods using large heavy equipment, such as tractor-borne hydraulic rams or jackhammers.
(*h*) **Installation of Neutron Probe Access Tubes in Stony and Bouldery Forest Soils,** R. G. Cline, B. L. Jeffers, *Soil Sci.* **120,** pp. 71-72, 1975.

Potential Water Yield Response Following Clearcut Harvesting on North and South Slopes in Northern Idaho, R. G. Cline, H. F. Haupt, G. S. Campbell, *Res. Paper INT-191*, Intermountain Forest and Range Experiment Station, Forest Service, USDA, 16 pages, 1977.

304-09323-830-00

TREE PLANTING FOR EROSION CONTROL ON GRANITIC ROADFILLS IN THE IDAHO BATHOLITH

(*c*) Dr. Walter F. Megahan, Project Leader, Intermountain Forest and Range Experiment Station, 316 E. Myrtle Street, Boise, Idaho 83706.
(*d*) Field investigations, applied research.
(*e*) Road erosion on road fill slopes is a major concern following road construction in the Idaho Batholith. The objectives of the present study were threefold, to measure the reduction in surface erosion following tree planting (ponderosa pine) with and without straw mulch; to provide information on tree survival and growth as affected by mulches, fertilizer, and tree spacing; and to define some of the basic soil erosion processes that are acting on granitic roadfills. The study consists of 30 1/200-acre plots

located on a large roadfill; four years of data are presently available for the analysis.
(*f*) Completed.
(*g*) Tree survival averaged about 97 percent for four years. Fertilizer increased tree height growth up to 95 percent during the year of peak effect. Tree planting, coupled with straw mulch and erosion netting, reduced surface erosion about 95 percent. Trees, alone, provided surprisingly large reductions in erosion, ranging from 32 to 51 percent. Daily erosion rates average higher during summer periods as compared to winter periods because of higher energy inputs. Dry creep is an important erosion process that accounts for about 20 percent of the total erosion occurring during summer periods.
(*h*) **Deep-Rooted Plants for Erosion Control on Granitic Road Fills in the Idaho Batholith,** W. E. Megahan, *Res. Paper INT-161*, Intermountain Forest and Range Exp. Sta., Forest Service, USDA, 22 pages, 1974.

304-09324-830-00

EFFECTS OF LOGGING AND ROAD CONSTRUCTION ON STREAM CHANNELS ON FORESTED WATERSHEDS IN THE IDAHO BATHOLITH

(*c*) Dr. Walter F. Megahan, Project Leader, Intermountain Forest and Range Experiment Station, 316 E. Myrtle Street, Boise, Idaho 83706.
(*d*) Field investigation, applied research.
(*e*) First- and second-order drainages in forested areas have the potential for storing considerable sediment because of large volumes of debris in the channel (rocks, logs, etc.). Sediment storage information is required if realistic sediment yield simulation models for forested lands are to be developed. The design includes a detailed network of channel cross sections on seven study watersheds. Numerous data are collected to characterize channel conditions.
(*g*) Four years of data are available for analysis. Sediment storage during a low-flow year amounted to approximately 80 cubic feet per 100 lineal feet of channel (channel widths average about 3-feet wide). During a high-flow year, sediment storage dropped to approximately 40 cubic feet per 100 feet of channel.
(*h*) **Sediment Storage in Channels Draining Small Forested Watersheds in the Mountains of Central Idaho,** W. F. Megahan, R. A. Nowlin, *Proc. 3rd Fed. Interagency Sedimentation Conf.*, Denver, Colo., pp. 4-115 to 4-126, Mar. 1976.

304-09325-810-00

EFFECTS OF CLEARCUT LOGGING AND ROAD CONSTRUCTION ON SUBSURFACE FLOW IN THE IDAHO BATHOLITH

(*c*) Dr. Walter F. Megahan, Project Leader, Intermountain Forest and Range Experiment Station, 316 E. Myrtle Street, Boise, Idaho 83706.
(*d*) Field investigation, applied research.
(*e*) Coarse-textured, relatively shallow soils; steep slopes; granitic bedrock with relatively low hydraulic conductivity; and large volume water inputs from snowmelt and/or large cyclonic storms are all conducive to the generation of subsurface flow. Road construction often incises the subsurface flow level, transforming subsurface to surface flow. This may interrupt the hydrologic function of the watershed containing the road, and has ecologic implications as well. Two micro-watersheds of 0.8 and 2.4 acres in size have been instrumented. Instrumentation includes a climatic station; snow lysimeters; a network of snow stakes, soil moisture access tubes and piezometers; and surface and subsurface flow measuring apparatus.
(*g*) No overland flow has been measured on either study watershed at any time. Subsurface flows occurred only during periods of large volume water inputs to the soils, and was restricted to the spring snowmelt periods. Maximum instantaneous peak flows have exceeded 20 cubic feet per second per square mile. Flows varied slightly between watersheds, but were vastly different between years. Yearly differences were related to amounts and rates of inflow. A comparison of nearby perennial watersheds suggests that the weathered and fractured granitic bedrock is more hydrologically active than previously thought. Interception of overland flow by roads is considerably greater than the flow generated by overland flow from the road surface itself.
(*f*) Data analysis in progress.
(*h*) **Subsurface Flow Interception by a Logging Road in Mountains of Central Idaho,** W. F. Megahan, *Proc. Symp. Watersheds in Transition*, Amer. Water Resources Assoc. and Colorado State Univ., *Proc. Series No. 14*, pp. 350-356, 1972.

304-09326-810-00

THE EFFECT OF LOGGING AND ROAD CONSTRUCTION ON STREAMFLOW, SEDIMENT PRODUCTION, AND WATER CHEMISTRY IN THE SILVER CREEK STUDY AREA, IDAHO BATHOLITH

(*c*) Dr. Walter F. Megahan, Project Leader, Intermountain Forest and Range Experiment Station, 316 E. Myrtle Street, Boise, Idaho 83706.
(*d*) Long-term laboratory and field investigation; applied research that will lead to prescriptions (practical applications) for land use management. Computer modeling of various land disturbances associated with logging and their off-site (downstream) effects is emphasized.
(*e*) Seven research watersheds treated in the southwestern Idaho Batholith have been monitored for a calibration period up to 15 years, including streamflow–quantity and regimen, sediment yield, water and sediment chemistry, and climate. Logging activities will commence in 1975 on a rigid, predetermined schedule to isolate single and multiple downstream effects of different logging systems (skyline and helicopter), differing cutting intensities (clearcut and select cut), and different attendant disturbances (roads vs. no roads; various slash disposal systems, etc.). The purpose of this project is to quantify off-site disturbances from advanced logging systems for future prediction.
(*g*) Accumulated baseline data on the undisturbed watersheds, including streamflow quantity and regimen; sediment production; water and sediment chemistry; and climatic data.

304-09327-390-00

SLOPE STABILITY OF PHOSPHATE MINE SPOIL DUMPS IN SOUTHEASTERN IDAHO

(*b*) Conducted in cooperation with College of Engineering, Utah State University, Logan, Utah.
(*c*) Mr. Paul E. Packer, Project Leader, Forestry Sciences Laboratory, 860 North 12th East, Logan, Utah 84321.
(*d*) Field and laboratory investigation, design and developmental research.
(*e*) With the development of large earth-moving equipment during the past decade, surface mining has increased very rapidly. Larger depths of overburden are being removed from above the ore mined. This overburden must be placed in spoil dumps, resulting in manmade fills, often involving considerably more cubic yardage than in large earth fill dams. The overburden removal may result in steep cuts to depths of hundreds of feet. In addition, earthen roads with widths comparable to super highways must be built for the heavy equipment to haul out the ore. All of these involve, in some form or another, the design, engineering, and placement of fills. Often these fills are given such cursory attention in the planning and construction phases that serious problems result from mass failures, massive erosion with heavy sediment loads carried by the runoff, and barren landscapes on which vegetation does not reestablish itself for many years–if at all.
Recognizing the existing conditions and potential future problems associated with slope stability of overburdened spoil dumps created during phosphate surface mining in southeastern Idaho, a study was undertaken to define and

delineate, in general terms, the design and construction criteria for building spoil dumps in the steep terrain of the phosphate mines in southeastern Idaho which will be stable against massive structural failure and result in minimum surface erosion and movement.

(*g*) In summary, the internal friction angle of the materials tested indicates mass failure of the dump created from the overburden should not be subject to massive failure if placed on slopes of three to one or less, even under relatively adverse pore pressure conditions. If no pore pressures are permitted to develop, the dump fills might even be stable if placed on steeper slopes up to 1.5 to 1. While the structural strength of the material is good (i.e., internal friction angles of 35° and above), it has low permeability and, consequently, is subject to high pore pressure if placed while at or near complete saturation. It will require about a year for pore pressures created in this manner to be dissipated.

The material contains relatively large amounts of silt-size grains, and, consequently, is susceptible to surface erosion. The material is also of the composition making it susceptible to frost action. With frost action loosening the surface material, its erodibility will be particularly great during the time of snowmelt and highest rainfall. The potential for large amounts of erosion during this season is great. Consequently, the slopes of the dump fills should be constructed taking into account the establishment of vegetation and minimization of erosion, as well as stabilizing against mass failure. Flatter slopes will generally be dictated by these latter considerations.

(*h*) **Slope Stability of Overburden Spoil Dumps from Surface Phosphate Mines in Southeastern Idaho,** R. W. Jeppson, R. W. Hill, C. E. Israelson, *Utah Water Res. Lab. Rept. RPWG 140-1*, 69 pages, April 1974.

304-10645-820-00

THE EFFECT OF ROAD CONSTRUCTION ON PIEZOMETRIC HEAD IN A TYPICAL IDAHO BATHOLITH SLOPE

(*c*) Dr. Walter F. Megahan, Project Leader, Intermountain Forest and Range Experiment Station, 316 E. Myrtle Street, Boise, Idaho 83706.

(*d*) Field investigation, applied research.

(*e*) A steep, forested slope has been instrumented with a series of piezometers. Two other stations are equipped with nuclear snow water, precipitation, and soil moisture sensing devices and with hygrothermographs. Piezometers were installed in three transects of 18 piezometers each, 2 years prior to road construction and logging. Transects are located up and down the slope and extend for a total distance of about 120 feet. After 2 years of undisturbed measures a road will be constructed through the middle of the transects and the area will be logged. Piezometer transects are located to evaluate the effects of treatment on piezometric head. Measurements will be continued after the disturbance for a 2 to 3-year period.

(*g*) An extremely low snowfall during the winter of 1976-77 resulted in no subsurface flow during the spring runoff period. Measurements in the undisturbed state will be continued for another year.

304-11422-810-00

THE EFFECT OF LOGGING AND ROAD CONSTRUCTION ON STREAMFLOW, SEDIMENT PRODUCTION, AND WATER CHEMISTRY IN THE HORSE CREEK STUDY AREA OF NORTH CENTRAL IDAHO

(*c*) Dr. Walter F. Megahan, Project Leader, Intermountain Forest and Range Experiment Station, 316 East Myrtle Street, Boise, Idaho 83706.

(*d*) Long-term laboratory and field investigation; applied research that will lead to prescriptions (practical applications) for land use management. Effects of timber harvest on streamflow rates, especially peak flows, and the resulting impacts on stream channel conditions is emphasized.

(*e*) Seventeen study watersheds are being monitored for streamflow and sediment yields in cooperation with the Nezperce National Forest. Ten watersheds averaging about 250 acres in size are located on south facing (high energy) slopes to evaluate the effects of timber harvest and road construction on peak flow rates and sediment yields. Five additional, similar sized watersheds, provide a comparative evaluation of timber harvest and road construction practices on north (low energy) slopes. Two additional study watersheds provide a comparison of the downstream integrated effects of small watershed treatments on watershed responses within a 4,100 acre watershed. Each of the three groups of study watersheds include at least one undisturbed drainage that will serve as a climatic control during the life of the study. Road construction began in 1978 and will continue in 1979. Logging activities will begin two years after road construction. Additional onsite studies provide information regarding road erosion and its control and the magnitude of channel sediment storage and associated impacts on aquatic habitat conditions.

(*f*) Continuing.

(*g*) Accumulated data includes continuous gauged streamflow, sediment yields in debris basins, instantaneous sediment measurements, water chemistry at selected intervals, measurement of aquatic environment conditions, onsite erosion, and climatic data.

U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, NORTH CENTRAL FOREST EXPERIMENT STATION, 1992 Folwell Avenue, St. Paul, Minn. 55108.

305-09332-870-00

LAND TREATMENT OF SEWAGE EFFLUENT AND SLUDGE ON FORESTS AND ASSOCIATED LANDS

(*b*) Some aspects of project are in cooperation with Michigan Department of Natural Resources.

(*c*) Dean H. Urie, USDA, Forest Service, North Central Forest Experiment Station, Stephen Nisbet Building, 1407 S. Harrison Road, East Lansing, Mich. 48823.

(*d*) Field investigations, basic and applied research.

(*g*) Application rates have been developed for applying sewage effluent and sludge to several Michigan forest types which allow for maintaining potable quality groundwater. Surface applied sludges have been shown to form a slowly decomposing organic layer from which nutrients slowly mineralize to provide long-term plant nutrient sources. Metals are also temporarily held in this residual. Phosphorus added through wastewater irrigation is held in unavailable forms in the surface layers of soil. Vegetative covers were successfully established on acid coal-mine spoil after heavy applications of sludge, however leave tissues were high in metals. Hybrid cottonwoods have incorporated about 100 lbs/year of nitrogen under sewage irrigation over a 5-year period. Silver maple and an orchard grass-crown vetch mixture provided the best cover on sludge amended mine spoil. Boron toxicity symptoms on pine needles have been the only adverse trace element effect noted from sewage treatment on forest lands.

(*h*) **The Effects of Sediment from a Gas-Oil Well Drilling Accident on Trout in the Williamsburg, Michigan Area,** G. R. Alexander, E. A. Hansen, *Mich. Dept. of Natl. Resources Fisheries Res. Report No. 1851*, 15 p., 1977.

Survival and Early Growth of Selected Trees on Wastewater Application Sites, J. H. Cooley, *USDA Forest Service Res. Note NC-231*, 4 p., 1978.

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305-11423-810-00

WATERSHED MANAGEMENT RESEARCH IN NORTHERN MINNESOTA

(*c*) E. S. Verry, USDA, Forest Service, North Central Forest Experiment Station, Grand Rapids, Minn. 55744.

(*d*) Experimental and field investigations; basic and applied research.

(*e*) Use basic hydrologic studies to develop management practices that will maintain or improve the quality and quantity of water yields from northern forest lands. Forest cultural practices (including timber harvesting, fertilization, use of herbicides, and prescribed burning) are studied to determine their effect on the water resources of northern conifer-hardwood forests. Of special concern will be the complex associations of uplands and bogs common to these forests. Methods will be developed for sampling and analyzing both surface and subsurface flows from treated areas. shallow water impoundments developed for wildlife habitat will be monitored and water level management guidelines developed to maximize desired habitat and minimize any adverse effects on water quality. The uses of natural peatland and peat materials in the treatment of sewage are being studied as possible solutions to the problem of inadequate and expensive sewage treatment facilities for communities, campgrounds and administrative sites.

(*g*) Fertilization of a young aspen stand with 150 to 450 lbs. of nitrogen per acre resulted in increased growth in height and basal area. This fertilization caused temporary increases of NO_3-N concentrations in a stream draining the area of up to 70 mg/l, but NO_3-N increases were not detected in a bog which receives runoff from the treated area and from which the stream flows. The fate of 2,4-D applied to an organic soil site is similar to data reported in the literature for mineral soils. Adsorption onto organic soils was weak. The rate of leaching depended upon 2,4-D formulation, soil pH, and soil type. Decomposition of a second application of 2,4-D occurred several times more rapidly than the first application due to adaptation of soil microorganisms. Growth and survival of *Alnus rugosa* (Du Roi) Spreng. and *Salix* Spp. L. were determined for two growing seasons with continuous flooding at different depths. Growth was at least four times greater when the water table was below the root crown than when it was 15 cm above the root crown. Mortality showed a similar relationship and was greatest for *A. rugosa*.

(*h*) **Precipitation Nutrients in the Open and Under Two Forests in Minnesota**, E. S. Verry, D. R. Timmons, *Can. J. For. Res.* **7**, pp. 112-119, 1977.

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Some Harvest Options and Their Consequences for the Aspen, Birch, and Associated Conifer Forest Types of the Lake States, L. F. Ohmann, H. O. Batzer, R. R. Buech, D. C. Lothner, D. A. Perala, A. L. Schipper, Jr., E. S. Verry, *USDA For. Serv. Gen. Tech. Rep. NC-48*, 34 pages, 1978.

U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, NORTHEASTERN FOREST EXPERIMENT STATION, 370 Reed Road, Broomall, Pa. 19008. David B. Thorud, Director.

306-0242W-810-00

MAINTAINING WATER QUALITY AND INCREASING SUMMER STREAMFLOW IN NEW ENGLAND HARDWOOD ECOSYSTEMS (Durham, N.H.)

See Water Resources Research Catalog 6, 3.0334.

306-0243W-810-00

PROTECTING WATER QUALITY AND IMPROVING WATER YIELDS FROM FORESTED LAND IN THE CENTRAL APPALACHIANS (Parsons, W. Va.)

See Water Resources Research Catalog 8, 3.0357.

306-09333-890-00

REDUCTION IN SURFACE-MINING DAMAGES TO FOREST RESOURCES BY IMPROVING MINING PROCEDURES AND REHABILITATION MEASURES (Berea, Ky.)

(*d*) Field investigations, basic and applied research.

(*g*) Measurements of sediment accumulation in debris basins below surface-mined lands in eastern Kentucky show highest sediment yield during the first 6 months after mining. The erosion rate diminishes to fairly low levels within 3 years. Methods of mining and handling spoil affect sediment yield, as does the speed with which vegetative cover is established. Samples collected weekly from six first-order streams in eastern Kentucky over seven water years were analyzed. Results indicate that baseline water quality can be adequately defined by sampling every 2 weeks for 1 year. Regression analyses indicated that specific conductance can be used to estimate the concentrations of dissoved solids and of dissociated ions such as calcium, magnesium, and sulfate. Eight years of streamflow data show the effects of strip mining on chemical quality of water in six first-order streams in Breathitt County, Kentucky. Data indicate that strip mining causes large increases in the concentration of most major dissolved constituents in the runoff waters, the concentration of most of these reaching a maximum some time after mining has

ceased, then holding steady for several years. Data from experimental sites in Breathitt County, Kentucky and Raleigh County, West Virginia, showed that during a major rainstorm on 4 April 1977 streamflow from surface-mined watersheds peaked lower than that from adjacent or nearby unmined watersheds. Research has shown that surface mining results in increases in storm peak flows during and immediately after mining but that peaks may be significantly lower after reclamation is completed. Impoundments on surface mine lands can be effective in controlling runoff and erosion provided the ponds are properly constructed.

(*h*) **Sampling for Water Quality,** W. R. Curtis, in *Natl. Bur. of Stand. Spec. Publ. 464, Methods and Stand. for Environ. Meas., Proc. of the 8th IMR Symp.*, Gaithersburg, Md., pp. 237-244, Sept. 20-24, 1976.

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Effects of Surface Mining on Hydrology, Erosion, and Sedimentation in Eastern Kentucky, W. R. Curtis, *4th Ky. Coal Refuse Disposal and Util. Semin.*, Pine Mountain State Resort Park, Pineville, Ky. (Sponsored by Univ. of Kentucky Coll. of Eng.) June 6-7, 1978.

306-09334-810-00

AMENITIES DERIVED FROM TREES, AND MULTIPLE-USE MANAGEMENT OF MUNICIPAL WATERSHEDS (University Park, Pa.)

(*c*) Edward S. Corbett, Principal Hydrologist, Armsby Building, Room 309, University Park, Pa. 16802.

(*d*) Field investigations; basic and applied research.

(*e*) The forested watersheds of Megalopolis are a major water-producing area. A recent survey of Northeastern Municipal Watersheds showed that two million acres of forest land are controlled and managed primarily for municipal water supplies. Major problem areas are water quality control, recreational use of municipal watersheds, and water yield improvement. Studies underway include the effects of vegetation type conversions on water quality and quantity; nutrient budgets; relative water use by overstory and understory vegetation; partial area hydrology; developing a fundamental understanding of hydrologic system linkages to assist in optimizing management objectives; developing guidelines for integrating uses such as production of quality water, recreation, aesthetics, timber and wildlife on municipal watersheds; and the disposal of waste water in woodlands. A substantial portion of the research is conducted in conjunction with municipal and state agencies, universities and the Consortium for Urban Research.

(*g*) Data from forested experimental watersheds in the eastern United States indicate that leaching of nutrients after timber harvesting, especially clearcutting, tends to increase from south to north, while increases in streamwater temperature and sediment loadings tend to decrease. Concentrations of nutrients in streamwater are highest where revegetation of cutover areas is delayed. Also, increased streamwater temperature caused by exposing stream channels may influence water quality by affecting a wide range of physical, chemical, and biological processes. Soil erosion losses from harvesting operations can be kept to acceptable levels by following available land-management guidelines. Buffer strips, in which only light selection cutting is allowed, will help minimize sedimentation as well as nutrient leaching and stream temperature increases.

(*h*) **Timber Harvesting Practices and Water Quality in the Eastern United States,** E. S. Corbett, J. A. Lynch, W. E. Sopper, *J. For.* **76**, 8, 484-488, 1978.

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Water Resources at the Forest Urban Interface PIEFR-PA-2, W. E. Sopper, J. A. Lynch, E. S. Corbett (eds.), U.S.D.A., For. Serv., Northeast. For. Exp. Stn., 47 p., 1977.

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U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION, P.O. Box 3141, Portland, Oreg. 97208. Robert F. Tarrant, Director.

307-04757-810-00

SOIL STABILITY AND WATER QUALITY OF MANAGED FOREST IN EASTERN OREGON AND WASHINGTON

(*c*) Dr. G. O. Klock, Project Leader.

(*d*) Field investigations; basic and applied research.

(*e*) Generate information necessary to develop prescriptions which maintain or enhance soil stability and water quality in the mid-Columbia River basin forests of eastern Oregon and Washington. Studies related to erosion reduction include (a) a study of vegetative recovery and succession after forest harvest in order to assess the role of various plant species in watershed stability, (b) evaluating mass wasting and soil erosion effects of roading, harvest and residue treatments, (c)characterizing nutrient distribution and cycling mechanisms and rates in order to determine effects of harvest on total site nutrient economy, and (d) determining ways to revegetate sites where severe erosion is in progress by evaluating moisture, temperature and nutrient requirements of various plant species. Studies related to water quality are concerned primarily with the effects of site disturbance such as road building and timber harvest on non-point source pollution. Non-point pollutants under study include sediment concentration, turbidity, and certain microbiological and chemical water quality.

(*g*) Survival and vigor of 14 common species of shrubs were evaluated for potential erosion control on disturbed sites in eastern Washington. Blue elderberry, bush penstemon, wild rose, and serviceberry had the highest survival rates. Vigor of blue elderberry and penstemon was good, but vigor of wild rose and serviceberry was only fair to poor. Defoliation by Douglas-fir tussock moths of up to 25 percent of the trees on three watersheds in the Blue Mountains of Oregon resulted in only minor changes in water quantity and quality. Placing black plactic mulch around each forest seedling when it was planted resulted in improved survival on relatively droughty sites, but because the extra effort doubled the planting time, the economic benefits are doubtful. Thermal regimes at several high elevation (1730 m) sites are examined following prescribed burn or mechanical removal of shading vegetation. Moderate increases in air temperature maxima at sensor height of 0.5 m were noted at treated locations while soil temperature maxima at 0.01 m increased by 8 °C on the grass slopes and by 26 °C in the burned snag patch. Double mass plots of accumulated degree hours illustrate the changing relationship between sites and indicate future trends as sited become revegetated. Chemistry of water flowing from three watersheds in North Central Watersheds, which were burned over by wildfire and later treated for erosion control, changed dramatically during the first three years following the fire. Concentrations of nitrate nitrogen, phosphorus, and four common cations increased significantly above pre-fire levels, but values were still within accepted concentrations for municipal water use. Soil fumigation was tried as a method to improve survival and growth rate of planted seedlings in an area where standard planting procedures have been unsuccessful. After five growing seasons, survival of Douglas-fir seedlings in the fumigated plot was 90 percent compared to 22 percent in the adjacent untreated plot. Height

growth was 250 percent greater in the fumigated plot. Reasons for the improved conditions after fumigation have not been determined, but increased nutrient availability through enhanced mycorrhiza associations is one hypothesis which needs testing. An extensive study evaluated the influence of defoliation on the environmental components of light, heat, moisture, and plant nutrient distribution within a mixed stand of grand fir and Douglas-fir. Marked changes were observed and quantified for all parameters measured. Computer analysis with prognostic models indicated that partial defoliation may lead to increased stand productivity within 20 years after defoliation. The computer results compare favorably with analyses of actual stand growth patterns following tussock moth defoliation in other areas. Various residue treatments following log removal can have serious impacts on the future site productivity of eastern Cascade soils. Early research results indicate that residue treatments can remove up to 28 percent of the total nitrogen, 61 percent of the extractable phosphorus, and 37 percent of the extractable potassium from the site.

(*h*) **Meeks Table Research Natural Area–Reference Sampling and Habitat Classification,** A. R. Tiedemann, G. O. Klock, *USDFA Forest Serv. Res. Pap. PNW-223*, 19 pages, illus. 1977.

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U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, PACIFIC SOUTHWEST FOREST AND RANGE EXPERIMENT STATION, P.O. Box 245, 1960 Addison Street, Berkeley, Calif. 94701, Robert Z. Callaham, Director.

308-04996-810-00

ENVIRONMENTAL HYDROLOGY, CONIFER ZONE

(*b*) Cooperative with U.S. Bureau Reclamation, National Aeronautics and Space Administration and Univ. California.

(*c*) Dr. James L. Smith, Project Leader, Environmental Hydrology, Conifer Zone.

(*d*) Experimental; field investigation; basic and applied research.

(*e*) Determine the relationships which exist between the climate and the snowpacks of the Sierra Nevada, and how these relationships are affected by the presence or absence of forest cover, so that the effect of forest cultural practices upon snow metamorphism and melt may be predicted in advance of application of such practices. Present studies emphasize study of snow density changes, water holding capacities, snow metamporphism and melt rates under a variety of meteorological and cover conditions, and the effect of these changes upon timing of delivery of water to streams. Determine effect of evaporation suppressants upon reduction of water losses from snowpacks under a variety of aspect-cover conditions. Determine effect of weather modification upon snowpacks of Central Sierra Nevada of California.

(*g*) Study of snowpacks under open and forested conditions shows that forest cover or its lack drastically affects both water holding capacity of snowpacks and delivery rate and pattern to the streams, either via the soil under the pack or through the snow, downslope over ice lenses. A manual is being prepared which land managers may use to plan harvests to accomplish desired objectives.

Analysis of snowpacks and simulation of potential snowpacks resulting from weather modification indicate that in the "warm" Sierra Nevada snow augmentation will only increase time snow remains on the land from 0 to 14 days.

(*h*) **Snowpack Evaporation Reduction–It's Possible, but Is It Practical?,** J. A. Baldwin, J. L. Smith, *Conf. on Sierra Nevada Meteorol.*, South Lake Tahoe, Calif., June 19-20, 1978, Preprints, 116-121P., illus., Am. Meteorol. Soc., Boston, Mass., 1978.

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Measurement of Liquid-Phase Water in Snow, W. I. Linlor, J. L. Smith, F. D. Clapp, (in press).

308-04998-810-00

PARAMETERS AFFECTING MANAGEMENT OF FORESTS ON UNSTABLE LANDS

(*b*) Cooperative with California Div. of Forestry and Humboldt State University.

(*c*) Dr Raymond M. Rice, Project Leader, Pacific Southwest Forest and Range Experiment Station, 1700 Bayview Drive, Arcata, Calif. 95521.

(*d*) Experimental, field investigations; basic and applied research.

(*e*) The Unit's mission is to gain an understanding of the hydrological and biological processes of the ecosystems of the north coast and Klamath Mountains of northern California and southern Oregon; and to develop information needed for integrated resource management consistent with protecting the resources and environment on unstable lands. Studies underway are aimed at developing methods for evaluating potential watershed damages from logging and road building, appraising the impact of logging and road building on anadromous fish habitats, and developing strategies for optimum monitoring of various nonpoint source pollutants.

(*g*) Analysis of 13 years of flood peaks from two experimental watersheds has confirmed that logging has a negligible effect on important flood events. Roads had been constructed in one of the watersheds and it had been selectively harvested over a 3-year period. The road construction was associated with no discernible change in flood runoff. During and following logging there were dramatic increases (over 300 percent) in small, mainly early season peaks but no change in large winter runoff events. Sediment discharge during the same period increased markedly. Road construction was associated with an 80 percent increase in sedimentation and logging was associated with a 275 percent increase. Preliminary investigations suggest that subsurface hydrology of logged areas may be chemically disturbed as a result of timber harvest. Phenolic compounds, which are some of the early decay products of wood, have been shown in laboratory tests to disperse clays. If operable in the field, this phenomenon might cause reduced hydraulic conductivity at critical layers in the soil profile.

(*h*) **Landslides and the Weathering of Granitic Rocks,** P. B. Durgin, *Rev. in Eng. Geol., 3:127-131*, illus., 1977.

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308-09335-810-00

FOREST AND WATERSHED RESOURCE MANAGEMENT RESEARCH IN HAWAII AND OTHER PACIFIC ISLAND AREAS

(*b*) Cooperative with Hawaii Department of Land and Natural Resources and University of Hawaii.

(*c*) Roger G. Skolmen, Project Leader, Timber and Watershed Management Research in Hawaii.

(*d*) Experimental; field investigations; basic and applied research.

(*e*) Research on effects of land use on watershed hydrology; effects of vegetation types on soil hydrology; stream sediment relationships to watershed vegetation cover; and water infiltration measurement systems.

(*g*) A paper soon to be published describes the suspended sediment yield of typical forested watersheds on Oahu, with some comparisons with an agricultural watershed. Annual yields range from approximately 100 to 1000 tons/sq. mi./yr., depending on the magnitude of 2 or 3 storms annually which produce the bulk of the sediment.

U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION, 240 W. Prospect Street, Fort Collins, Colo. 80526.

309-02658-810-00

WATER YIELD AND QUALITY IN THE BLACK HILLS AND REVEGETATING MINE SPOILS ON THE HIGH PLAINS

(*b*) Environmental Protection Agency.

(*c*) Ardell J. Bjugstad, Project Leader, Forest Research Laboratory, South Dakota School of Mines and Technology.

(*d*) Experimental; basic and applied research.

(*e*) Determine geologic, geomorphic, and forest factors that influence or relate to quantity and timing of the water yield and reclamation of surface mine spoils.

(*h*) **The Impact on Air Quality of Coal Consuming Facilities,** T. E. Amundson, *Masters Thesis*, Dept. Mech. Engrg., North Dakota State Univ., Fargo, N.D., 94 pp., 1977.

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309-03569-810-00

WATERSHED MANAGEMENT RESEARCH, LARAMIE, WYOMING

(*b*) Bureau of Land Management; Wyoming Highway Department.
(*c*) Ronald D. Tabler, Project Leader.
(*d*) Field investigation; applied research.
(*e*) Water yield characteristics of big-sagebrush lands are being studied on plots and gaged watersheds, and hydrologic effects of control measures are being determined. Methods for increasing snow accumulation in windswept areas are also being developed and tested.
(*h*) **Soil Water Withdrawal and Root Characteristics of Big Sagebrush**, D. L. Sturges, *Amer. Midland Naturalist* **98, 2:257-274, 1977.**
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309-09338-810-00

MULTI-RESOURCE MANAGEMENT OF SUBALPINE CONIFEROUS FORESTS, FORT COLLINS, COLORADO

(*c*) Robert R. Alexander, Project Leader.
(*d*) Experimental, field investigations, basic and applied research.
(*e*) Develop systems for integrating available and newly developed information into decision-making tools for land management and planning, and predict the effects of vegetation manipulation on water yield and quality.
(*h*) **The Front Range Pine Type: A 40-Year Photographic Record of Plant Recovery on an Abused Watershed**, H. L. Gary, P. O. Currie, *USDA For. Serv., Gen. Tech. Rep., RM-46*, 17 p., 1977.
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309-10648-810-00

SNOWDRIFT MANAGEMENT AND AVALANCHE HAZARD EVALUATION

(*b*) Colorado State University.
(*c*) M. Martinelli, Jr., Project Leader.
(*d*) Experimental and field investigation; applied research.
(*e*) Determine methods for predicting and controlling the transport and deposition of the snow by winds in order to modify natural drift patterns for managerial or safety purposes. Improve the evaluation and forecasting of avalanche hazard to reduce the danger from snow avalanches in winter recreation areas, mountain highways, mining operations and mountain home sites.
(*g*) A numerical hydrological model of avalanche motion has been developed for the prediction of avalanche velocity, runout distance, and impact force. The same model had been used to study the placement of jet roofs on ridges to eliminate cornice development. A simulation model to predict avalanche hazard based on weather, snow and terrain factors has been developed and is being tested. Guidelines have been developed for the location and construction of avalanche control structures in the lower track and runout zone. A chronicle has been prepared of historic snow avalanches in the Front Range and Central Mountains of Colorado.
(*h*) **A System that Measures Blowing Snow**, R. A. Schmidt, *USDA For. Serv. Res. Note RM-194*, 80 pages, 1977.
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U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, SOUTHEASTERN FOREST EXPERIMENT STATION, P.O. Box 2570, Asheville, N. C. 28802. Eldon W. Ross, Director.

310-0247W-810-00

WATER, SOIL, AND AQUATIC RESPONSES TO MANAGEMENT OF SOUTHERN APPALACHIAN-PIEDMONT FORESTS

(*b*) Cooperative with the University of Georgia, Clemson University, Georgia Institute of Technology, Duke University, Virginia Polytechnic Institute and State University, Western Carolina University, Colorado State University, Oak Rdige National Laboratory, Man and the Biosphere

Program, Tennessee Valley Authority, N C. Department of Natural Resources and Community Development.

(c) James E. Douglass, Project Leader, USDA Forest Service, Coweeta Hydrologic Laboratory, P.O. Box 601, Franklin, N.C. 28734.

(d) Field investigation; applied research.

(e) Investigations to document and explain water and aquatic resource responses to intensive management of southern Appalachian and Piedmont forests, and to identify management practices which protect these resources. Hydrologic research is aimed at quantifying sediment, nutrient, and chemical losses resulting from timber harvesting, mechanical site preparation, burning, pesticide applications, and road construction. A second objective focuses on identifying the biological, chemical, and physical interactions which determine productivity of trout streams. Water yield, sediment production, and stream chemistry are monitored through a network of 13 permanently gaged watersheds (9- to 760-ha) in the southern Appalachians. An additional 25 temporarily gaged, small watersheds (1- to 2-ha) are being utilized for short-term studies in the Piedmont of North Carolina, South Carolina, and Georgia.

(g) Highlead cable logging of a steep Appalachian watershed disturbed 2 to 5 percent less mineral soil than careful tractor logging. A heavy layer of 8-cm gravel reduced erosion from a bare-soil road surface by a factor of 200. KG clearing with and without disking to prepare Piedmont sites for planting pine increased erosion rates by factors of 10 or more compared with undisturbed forests. A conceptual framework of elemental cycles was successfully applied to analyses of the nitrogen cycle in deciduous hardwoods and loblolly pine. Precipitation inputs and streamflow outputs of nitrogen, calcium, potassium, magnesium, and sodium were compared for two deciduous forest watersheds in the Appalachian region and a coniferous forest watershed in the Pacific Northwest. While nitrogen inputs varied nearly tenfold, nitrogen discharge was uniformly small. Cation discharge was more variable than input and strongly related to bedrock type. A 4-year study of five small trout streams indicated that the cover variables were consistentlly better predictors of trout biomass than water type or current velocity. Measurement of naturally occurring populations of enteric bacteria in mountain streams fluctuated seasonally and diurnally, and were correlated with stream turbidity and temperature.

(h) **Site Preparation Alternatives: Quantifying Their Effects on Soil and Water Resources,** J. E. Douglass, *Proc. Site Prep. Workshop, East.*, Raleigh, N.C., pp. 43-45, Nov. 1977.

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Nutrient Budgets for Undisturbed and Manipulated Hardwood Forest Ecosystems in the Mountains of North Carolina, W. T. Swank, J. E. Douglass, *Watershed Res. in East. North Am.: A Workshop to Compare Results* **I,** Edgewater, Md., pp. 343-364, 1977.

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U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, SOUTHERN FOREST EXPERIMENT STATION, T-10210 Postal Services Building, 701 Loyola Avenue, New Orleans, La. 70113. Laurence E. Lassen, Director.

311-06973-810-00

MULTI-RESOURCE MANAGEMENT OF FORESTS IN THE OZARK-OUACHITA HIGHLANDS

(b) Cooperative with the University of Arkansas.

(c) Dr. Edwin R. Lawson, Project Leader, U.S. Forest Service, Southern Forest Experiment Station, 830 Fairview St., Fayetteville, Arkansas 72701.

(d) Field investigations; applied research.

(e) To formulate forest management alternatives to enhance values of water, timber and related forest resources. Hydrologic research is aimed at determining the effects of various silvicultural measures on streamflow and water quality. Measurement of hydrologic responses from partial and complete vegetation removal on three small watersheds in the Quachita Mountains has been completed. Hydrologic responses to planting pine and natural regeneration on these watersheds are now being studied. Calibration of three watersheds in the Springfield Plateau has been completed and two silvicultural treatments have been applied. Calibration of four watersheds in the Boston Mountains is continuing. Nine additional watersheds are being used to determine the effects of clearcut and selection silvicultural systems on several resources. Soil water, surface runoff, sediment losses and nutrient losses via runoff are being monitored.

(g) Results indicate significant increases in soil water and runoff following partial and complete vegetation removal from the Ouachita Watersheds. Sediment losses increased immediately after timber removal, but returned to pretreatment levels in three years. Herbicide residues in runoff were detected in only one of three years and they were minimal and of short duration. Diameter growth of shortleaf pine was significantly increased as a result of understory removal and thinning the pine overstory. Soil water deficits in northern Arkansas were significantly different on forested and clearcut areas, but were no different on northwest and southeast aspects. Growing season deficits on forested areas were over four times those on

cut areas. Spring deficits were very similar under both cover conditions.

(*h*) **Hydrologic Characteristics of Mixed Hardwood Catchments in the Ozark Plateau,** T. L. Rogerson, *Proc. Central Hardwood Forest Conf.*,pp. 327-333, 1976.

311-06974-810-00

HYDROLOGIC EVALUATION OF FOREST MANAGEMENT ALTERNATIVES FOR THE SOUTHERN COASTAL PLAIN PINERY

(*c*) Stanley J. Ursic, Project Leader, U.S. Forest Service, Forest Hydrology Laboratory, P.O. Box 947, Oxford, Miss. 38655.

(*d*) Field investigation; applied research.

(*g*) On pine-forested catchments, annual inputs from precipitation exceeded losses of all major dissolved nutrients in stormflows. Log skidding compacted soils sufficiently to temporarily increase overland flows and erosion; 8 to 12 years were required for natural recovery. From 5 pine forested catchments not recently disturbed, phosphorus (P) in solution in stormflows averaged 0.027 mg/l, closely approaching maximum allowable recommended by Council on Environmental Quality. Sediment-associated P ranged from 274 to 1,067 μg/g of sediment and accounted for two-thirds of total annual P yields (solution plus sediment). Sediment from planted loblolly pine forests did not differ significantly from that from natural shortleaf pine forests. Annual sediment concentrations from unstocked forest lands and those supporting poor-quality hardwoods averaged four times concentrations from pine forests.

(*h*) **Potential Effects of Forest Management Practices on Stormflows Sources and Water Quality,** R. S. Beasley, *Proc. Miss. Water Resour. Conf.*, pp. 111-117, Miss. State Univ., 1976.

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DEPARTMENT OF THE ARMY, COASTAL ENGINEERING RESEARCH CENTER, CORPS OF ENGINEERS, Kingman Building, Fort Belvoir, Va. 22060. Andre Szuwalski, Coordinator, Coastal Engineering Information Analysis Center.

312-02193-490-00

COASTAL CONSTRUCTION-DEVELOP FUNCTIONAL/STRUCTURAL DESIGN CRITERIA

(*c*) R. A. Jachowski, Chief, Coastal Design Criteria Branch, Engineering Development Division.

(*d*) Applied research and engineering design development.

(*e*) Development of functional and structural design criteria is directed at summarizing for design application, information obtained through research by the Corps and others, compiling and synthesizing it, and finally translating it into a form directly usable by coastal engineers, and in a sense, is the end product of all CERC's research.

(*g*) The following projects have been completed and the final reports are being prepared for publication: An Annotated Bibliography on Detached Breakwaters and Artificial Headlands; An Annotated Bibliography of Patents (1967-1976) Related to Coastal Engineering; Wave Runup on Roughened Slopes. The following Coastal Engineering Manual (Special Reports) have been completed and the final manuscripts are being prepared for publication: Coastal Hydraulic Models; Tides and Tidal Datums in the United States; Tsunami Engineering; Marsh Creation Along the Coasts of the Continental United States. Work continues on the preparation of other reports in the Coastal Engineering Manual Series.

(*h*) **U.S. Army, Corps of Engineers, Coastal Engineering Research Center,** *Shore Protection Manual*, 3rd Edition, Vols. I, II, III, Stock No. 008-022-0113-1, U.S. Government Printing Office, Washington, D.C., 1977.

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A Method for Estimating Wind-Wave Growth and Decay in Shallow Water With High Values of Bottom Friction, F. E. Camfield, *Coastal Engineering Technical Aid, No. 77-6*, Oct. 1977.

312-02195-430-00

EVALUATION OF SHORE PROTECTION STRUCTURES

(*c*) J. R. Weggel, Chief, Evaluation Branch, Engineering Development Division.

(*d*) Field investigation; applied research.

(*e*) Evaluation of Shore Protection Structures is directed at providing improved functional design criteria for coastal projects through analysis of the behavior of selected prototype structures which have been built. Current design practice depends on many empirical relationships and coefficients that are generally based on insufficient data. By evaluating structure performance, techniques which have been obtained through empirical or analytical efforts can be confirmed, and the accuracy of coefficients determined. Data are collected before, during and after construction of shore structures, including repetitive surveys,

material sampling, littoral forces (to the extent possible), and the techniques and materials of construction. Analysis of these data is aided by the use of electronic data processing techniques.

(g) Data processing continued for the following locations: North Carolina Beaches–beach behavior and beach fill performance; Murrells Inlet, N.C.–weir jetty performance; Little River, S.C.–weir jetty performance; Lorain, Ohio, Lakeview Park–beach fill behind three detached breakwaters; Texas coast inlets and Lake Michigan–southeast shore.

312-06995-880-00

COASTAL ECOLOGICAL STUDIES

(c) E. J. Pullen, Chief, Ecology Branch, Research Division.

(d) Field investigations; applied research.

(e) Eight work units representing ecological problem areas are under study. Four are concerned with coastal vegetation and four with marine animals.

(g) The work units are listed as follows:

Foredune Ecology: To define and evaluate the impacts of foredune construction upon the biotic communities of the beach and landward areas of barrier islands including adjacent shallow water areas of lagoons and sounds.

Bank Erosion Control With Vegetation: To provide a natural, inexpensive, efficient method of bank erosion protection by use of living plants in areas of relatively low wave energy.

Ecological Effects of Beach Nourishment: To define and quantify the ecological effects of beach nourishment operations in southern California, Atlantic and Florida Gulf coastal areas and the Great Lakes and make that information available for planning and management purposes; to provide beach nourishment guidelines that adequately consider the effects of initial obtention (i.e., dredging) of beach fill material, and the effect of sand emplacement on the living resources of the operations area such as clam beds of commercial or recreational value and other animals in the sandy bottom or attached to nearby hard surfaces. Longterm ecological effects of sand emplacement and borrow pit creation are considered in this work unit.

Coastal Engineering Uses of Submerged Plants: To assess existing propagation and planting techniques for submerged plants such as eelgrass, turtlegrass and widgeon grass and determine the feasibility of planting such grass beds to stabilize disturbed bottom, attenuate wave energy (short period waves), create habitat for animals important to the food chain and trap sediment before it enters navigation channels and harbors.

Effects of Channel Deepening and Jetties on Fish and Shellfish Migration. Determine how widening and deepening inlet channels and building jetties affect the migration of commercial and sport species of marine fish and shellfish in and out of coastal estuaries.

Ecological Effects of Rubble Structures: To define and quantify the ecological effects of rubble groins, jetties, and breakwaters in four U.S. coastal areas and the Great Lakes.

Effects of Construction and Operation of Field Research Facility: To define, quantify and document the ecological effects of the construction and initial operation of the CERC research pier on the biota of Currituck Banks, N.C.

Productivity of Western Salt Marshes: To obtain secondary productivity information for Pacific Coast marshes, and compare the information with east coast marsh productivity.

(h) **Preliminary Analysis of Urban Waste, New York Metropolitan Region,** M. G. Gross, *Technical Rept. No. 5*, Marine Science Research Center, State University of New York, Stony Brook, Mar. 1970, 35 pp., NTIS AD No. 746959.

Effects of Suspended and Deposited Sediments on Estuarine Organisms, J. A. Sherk, Jr., J. M. O'Connor, *Chesapeake Biological Laboratory Reference No. 71-4D*, Natural Resources Institute, Univ. of Maryland, College Park, Md., 1971, 31 pp. and Appendices.

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gineers, Coastal Engineering Research Center, Fort Belvoir, Va., July 1977. NTIS AD No. A043875.
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312-09733-410-00

BEACH PROFILE STUDIES

(*c*) Allen DeWall, Coastal Processes Branch, Research Division.
(*d*) Field investigation; applied research.
(*e*) Develop criteria for the design of protective sand beaches, and a predictive model that will provide early warning of potentially dangerous beach depletion. The primary source of data is repetitive surveys of beach profile lines at selected coastal localities. This profile data is correlated with environmental factors such as wave, tide, storm and sand conditions, to the extent that they are known, and with engineering works, such as beach fills and groins.
(*g*) Results to date include two reports which are the first in a series on beach changes at various localities along the U.S. east coast. These two reports–on the southeast coast of Florida, and Westhampton Beach, N.Y.–summarize the results of repetivive beach surveys collected at intervals ranging from daily to monthly for up to 10 years. The data have been analyzed for short-term (i.e., storm and seasonal) changes and long-term (year-to-year) changes of the shoreline and sand volume on the beach and in the nearshore region.
(*h*) **Size Analysis of Sand Samples From Southern New Jersey Beaches**, M. D. Ramsey, C. J. Galvin, *U.S. Army Coastal Engineering Research Center MR 77-3*, Mar. 1977.
Littoral Environment Observations and Beach Changes Along the Southeast Florida Coast, A. E. Dewall, *U.S. Army Coastal Engineering Research Center TP 77-10*, Oct. 1977.
Beach and Nearshore Processes in Southeastern Florida, A. E. Dewall, J. J. Richter, *Coastal Sediments 77 Conference*, Nov. 1977.
Spatial and Temporal Changes in New Jersey Beaches, C. H. Everts, M. T. Czerniak, *Coastal Sediments 77 Conference*, Nov. 1977.
Geometry of Profiles Across Inner-Continental Shelves of the Atlantic and Gulf Coasts of the United States, C. H. Everts, *U.S. Army Coastal Engineering Research Center TP 78-4*, July 1978.
Beach Changes at Westhampton Beach, N.Y., 1962-1973, A. E. Dewall, unpublished manuscript, July 1978.

312-09735-470-00

ALASKA HARBOR RESEARCH (SEDIMENTATION IN HIGH TIDE RANGE AREAS)

(*c*) Dr. Craig Everts, Chief, Geotechnical Engineering Branch, Engineering Development Division.
(*d*) Field investigation; applied research.
(*e*) Prediction of shoaling rates for Alaskan harbors prior to their construction, the application of this knowledge to siting harbors in areas of least shoaling, and improved guidelines for harbor design. Field data from Nushagak Bay, Kenai and Knik Arm, Alaska, have been collected. Included are data on sediment concentration, sediment size distribution and density; water salinity and temperature; water current velocity, wave characteristics, ice tidal elevations, estuary bathymetry, tidal flat topography, tidal flat sediment characteristics and time changes in tidal flat surface elevation. Shoaling rates have been measured in a sedimentation test facility and in a prototype Alaskan half-tide harbor. The resulting data are being analyzed and techniques to predict shoaling rates have been developed. Guidelines for harbor design are now available. Work on harbor siting continues.
(*g*) Results to date include a better understanding of the factors contributing to shoaling and design of certain enclosed harbors.
(*h*) **Shelf-Maintaining Navigation Channels for Certain Enclosed Harbors**, C. H. Everts, *Proc. 4th Intl. Conf. Port and Ocean Engineering Under Arctic Conditions*, St. John's Newfoundland, Sept. 1977, pp. 382-393.

312-09736-410-00

SEAWARD LIMIT OF EFFECTIVE SEDIMENT TRANSPORT

(*c*) R. J. Hallermeier, Coastal Processes Branch, Research Division.
(*d*) Experimental, theoretical and field investigations; basic and applied research.
(*e*) To define, in operational terms, a zone seaward of which wave-induced sediment transport can be considered negligible for coastal engineering purposes. The seaward and landward edges of this zone will be established using laboratory results on sediment-hydraulic interactions in unbroken waves, and checked against field results.
(*g*) Tests in a water tunnel at the National Bureau of Standards investigated sand motion initiation and bed form development with three quartz sands and a range of prototype flow periods. The Shields criterion for steady-flow motion initiation was found to need modification in oscil-

latory flow. A simple relationship was reported for the maximum number of wave cycles required for fully-grown sand ripples. Further office evaluation established a lack of scale effect and of influences of other ignored variables in a calculated maximum water depth for nearshore erosion. These results justify certain uses of the limit depth in designing laboratory and field projects.

(*h*) **Sediment Suspension and Turbulence in an Oscillating Flume,** T. C. MacDonald, *Technical Paper No. 77-4*, U.S. Army Coastal Engineering Research Center, 1977, 80 pp.
Sand Ripple Growth in an Oscillatory-Flow Water Tunnel, K. E. B. Lofquist, *Technical Paper No. 78-5*, U.S. Army Coastal Engineering Research Center, 1978, 101 pp.
Uses For a Calculated Limit Depth to Beach Erosion, R. J. Hallermeier, *Proc. 16th Intl. Coastal Engineering Conference*, Chapter 88, Hamburg, Germany, 1978, 20 pp.

312-09742-440-00

EFFECTS OF LONG-TERM GREAT LAKES WATER LEVEL CHANGES

(*c*) William A. Birkemeier, Coastal Processes Branch, Research Division.
(*d*) Field and office investigation; applied research.
(*e*) Evaluation of beach effects, especially bluff recession resulting from the current high lake levels, and the prediction of probable beach changes that will occur during future episodes of high lake levels. Field surveys of 17 profile lines along the eastern coast of Lake Michigan were made at four-week intervals between 1970 and 1974. These data have been correlated with environmental factors such as lake level, wave conditions and foreshore and backshore sand samples. In addition semiannual aerial photographs of 5 miles of the Berrien County, Michigan shoreline are being studied to evaluate the temporal and alongshore variations in the shore and bluff lines between 1970 and 1974.
(*g*) Results to date include several reports that point out that bluff recession is highly variable along the shoreline and that the largest changes occur during late fall and early spring.
(*h*) **Bluff and Shore Erosion, Including the Effects of Lake Level and Structures, in Berrien County, Michigan 1970-1974,** W. A. Birkemeier, in prep., CERC, 113 p.

312-09744-410-00

CHECKLIST FOR LONGSHORE TRANSPORT PREDICTION

(*c*) Philip Vitale, Hydraulic Engineer, Research Division.
(*d*) Experimental; development.
(*e*) Develop a checklist for computing longshore transport rates to be used by engineers in Corps Districts and Divisions. Laboratory, field and office procedures will be used to evaluate existing methods for the prediction of longshore transport rates. Laboratory and field procedures will be used to test critical questions and office studies will be used to document and evaluate methods. Particular items include documentation of the existing longshore energy flux method; laboratory tests to compare energy flux with longshore force as a predictor of transport rates; evaluation of the relative importance of suspended sediment in contributing to total longshore transport rate; preparation of a recommended check list for longshore transport rate prediction. Each of these four items would be accompanied by a report documenting the results obtained.
(*g*) The field measurements of suspended sediment, report TP 77-5, presents suspended sediment concentrations for various wave characteristics and sediment properties. Concentrations up to 4 parts per thousand were found. The friction factor over sand beds in a water tunnel was empirically expressed as a function of bottom water particle displacement, grain size, and ripple height.
(*h*) **Suspended Sediment in the Littoral Zone at Ventnor, New Jersey, and Nags Head, North Carolina,** J. C. Fairchild, *Coastal Engineering Research Center TP 77-5*, May 1977.

312-09746-410-00

BEACH FILL SEDIMENT CRITERIA

(*c*) R. D. Hobson, Geotechnical Engineering Branch.
(*d*) Applied research involving theoretical and field investigations.
(*e*) Provide guidelines for District use in scheduling optimum available material for beach fills and to determine amount of material required. To obtain and analyze field and model data in order to improve the characterization of littoral materials as guidance for specifying, in BEC studies those materials which will provide a more stable beach considering slope, wave, and current regime of a particular coastal sector. Information will be summarized in form of charts and tables suitable for engineers in planning, design, construction, and maintenance of beaches. To attain objectives, investigation includes collection of data related to temporal and spatial changes in beach and offshore profiles, as well as beach and offshore sediment characteristics; additionally, temporal modifications to the profile and sediment at beach nourishment/fill/bypass operations will be monitored. Data obtained will be analyzed and information incorporated into conceptual and mathematical models for interaction to subsequent field data collection programs. Field data from the Atlantic, Gulf, Pacific, and Great Lakes will be obtained. Because a large number of sediment samples will need to be analyzed investigation of temporal and spatial variability of sediment textural properties will be examined in order to assess sampling error, measurement error, information loss through data processing so as to improve the quality of sediment textural data collected by and stored at CERC and used as prime data base for this work unit.
(*g*) Mathematical models have been developed to predict average requirements and renourishment needs by comparing composite granulometric properties of native beach and borrow source sediments. Effects of sediment handling techniques or model predictions are also being investigated. Field studies, including monitoring the performance of selected projects, are being conducted to test the models.

312-09747-710-00

COASTAL IMAGERY DATA BANK

(*c*) A. Szuwalski, Coordinator, Coastal Engineering Information Analysis Center, Technical Information Division.
(*d*) Field investigation, operational development.
(*e*) Proposed project is to index available controlled aerial photography of coastal and estuarine areas of the United States.
(*g*) The indexing as described in (e) above is done on a U.S. Army Corps of Engineers District area basis. Indexing for the following Engineer Districts is complete: NAB, SAN, NPS, NPP, SPN, SAJ, NAO, SAW, NAP, NCB, NCE, NCC, NCS, NAN, SAM, and LMN.

312-09751-410-00

GENERAL INVESTIGATION OF TIDAL INLETS

(*c*) R. M. Sorensen, Chief, Coastal Structures Branch, Research Division.
(*d*) Experimental; theoretical, and field; applied research and development.
(*e*) Determine the effects of wave action, tidal flow, and related forces on inlet stability and on the hydraulic, geometric, and sedimentary characteristics of tidal inlets; to develop the knowledge necessary for design of effective navigation improvements and new inlets; to evaluate the water transfer and flushing capability of tidal inlets; and to define the processes controlling inlet stability.
(*f*) Completed.
(*g*) An office study was being conducted to classify inlets on the basis of their geometry, hydraulics, and stability. The hydraulic characteristics of a number of idealized inlet configurations were defined. An evaluation of physical and mathematical modeling capabilities for prediction of inlet hydraulics was conducted, as well as an evaluation of the

state-of-the-art of inlet movable bed modeling. Field data from a number of inlets was collected and analyzed to define the significant processes controlling the dynamics and hydraulics of tidal inlets.

(*h*) The reports listed below have been published and are available from NTIS:

Comparison of Numerical and Physical Hydraulic Models, Masonboro Inlet, North Carolina, D. L. Harris, B. R. Bodine, *GITI Report 6*, June 1977.

Fixed-Bed Hydraulic Model Results Appendix 1, R. A. Sager, W. C. Seabergh, *GITI Report 6*, June 1977.

Numerical Simulation of Hydrodynamics (WRE) Appendix 2, Volume 1, F. D. Masch, R. J. Brandes, J. D. Reagan, *GITI Report 6*, June 1977.

Numerical Simulation of Hydrodynamics (WRE) Appendix 2, Volume 2, F. D. Masch, R. J. Brandes, J. D. Reagan, *GITI Report 6*, June 1977.

Numerical Simulation of Hydrodynamics (Tracor) Appendix 3, R. J. Chen, L. A. Hembree, Jr., *GITI Report 6*, June 1977.

Simplified Numerical (Lumped Parameter) Simulation Appendix 4, C. J. Huval, G. L. Wintergerst, *GITI Report 6*, June 1977.

Hydraulics and Dynamics of New Corpus Christi Pass, Texas; A Case History 1972-73, E. W. Behrens, R. L. Watson, C. Mason, *GITI Report 8*, Jan. 1977.

Laboratory Investigation of Tidal Inlets on Sandy Coasts, R. E. Mayor-Mora, *GITI Report 11*, Apr. 1977.

A Case History of Port Mansfield Channel, Texas, J. M. Kieslich, *GITI Report 12*, May 1977.

Hydraulics and Stability of Tidal Inlets, F. F. Escoffier, *GITI Report 13*, Aug. 1977.

A Spatially Integrated Numerical Model of Inlet Hydraulics, W. N. Seelig, D. L. Harris, *GITI Report 14*, Nov. 1977.

Physical Model Simulation of the Hydraulics of Masonboro Inlet, North Carolina, R. A. Sager, W. C. Seabergh, *GITI Report 15*, No. 1977.

Hydraulics and Dynamics of North Inlet, South Carolina, 1975-76, D. Nummedal, S. M. Humphries, *GITI Report 16*, Sept. 1978.

312-09752-410-00

CHANNEL ISLANDS LONGSHORE TRANSPORT STUDY

(*c*) J. R. Weggel, Chief, Evaluation Branch, Engineering Development Division.

(*d*) Field investigation, applied research.

(*e*) Data including repetitive surveys, sand samples and wave climatology are collected at the Channel Islands Sand Trap area. The purpose is to determine an empirical relationship between longshore energy flux and longshore material transport.

(*g*) A preliminary analysis of the recently acquired data indicated that (transport versus energy flux) points plot above the existing (Shore Protection Manual) relationship. This relationship is a reasonable approximation to the actual relationship. A new integrated survey system technique was tested at the study site. This system computes horizontal positioning of the survey vessel, sounding depth and transmits the data via radio to a shore based office. At the shore based office the incoming data is processed in real time by a mini-computer and stored on magnetic tape for processing immediately upon completion of the survey. This system allows the survey vessel to be guided along a preselected course by plotting the position of the vessel on a scope which is located in the shore based office.

312-09756-420-00

STORM SURGE CALCULATIONS

(*c*) J. M. Hubertz, Oceanography Branch, Research Division.

(*d*) Theoretical and experimental applied research.

(*e*) A two-dimensional vertically integrated explicit numerical model to predict tidal and/or surge water levels and currents in a coastal region has been developed. The model allows for flooding and recession, the use of subgrid scale exposed or submerged barriers and the use of subgrid scale channels. In the storm surge mode, the model is driven by a hurricane wind field model which allows for modification of wind speed due to land effects. The model is being used to aid in the design of various projects near the coast.

(*f*) Completed.

(*g*) Applied to Corpus Christi Bay area to predict changes in water level due to proposed modifications of dredged channels.

(*h*) **Development of Surge II Program With Application to the Sabine-Calcasieu Area for Hurricane Carla and Design Hurricanes,** R. O. Reid, et. al., *CERC TP No. 77-13*, 1977.

312-09761-410-00

INNER CONTINENTAL SHELF SEDIMENT CHARACTERISTICS

(*c*) S. J. Williams, Geotechnical Engineering Branch.

(*d*) Applied research involving field investigations.

(*e*) To determine the characteristics and distribution of materials comprising the sea floor and subbottom of U.S. inner continental shelves and Great Lakes in the zone shoreward of approximately the 120 foot (35 meter) depth contour for purposes of identifying materials or deposits suitable for beach fill or periodic nourishment, other needs, and relationships of sediment characteristics to regional geomorphology. To attain objectives, investigations include collection of high resolution seismic data and nominal 20-foot (6 meter) long cores of the subbottom material. These data are analyzed to determine sediment characteristics and areal extent of sand suitable for beach restoration or periodic nourishment purposes; collected data are also analyzed to better understand the sediment and regional geomorphology of the coastal segment under study. Because constraints for obtaining borrow material for beach fill purposes located inland or in backshore coastal zones are becoming more rigid, there is a need to perform the ICONS study along the entire Atlantic, Gulf, Pacific, and Great Lakes coastal regions. To date, about 30 percent of these areas have been surveyed, the data analyzed and reports prepared.

(*g*) Studies of the U.S. inner continental shelf, conducted to date along most of the Atlantic coast and along the coast of southern California, have delineated nearly 12 billion cubic meters of sand suitable for beach restoration projects. Additional field programs are planned for the remainder of southern California in 1979 and 1980.

(*h*) **Geologic Effects of Ocean Dumping on the New York Bight Inner Shelf,** S. J. Williams, *Ocean Dumping and Marine Pollution*, edited by H. D. Palmer and M. Grant Gross, pp. 51-72.

Sand Resources of Southeastern Lake Michigan, E. P. Meisburger, S. J. Williams, D. P. Prins, CERC technical publication in press (1979).

Sediment Distribution, Sand Resources, and Geologic Character of the Inner Continental Shelf off Galveston County, Texas, S. J. Williams, D. A. Prins, E. P. Meisburger, CERC technical publication in press (1979).

Sand and Gravel Resources and Geologic Character of Lake Erie–Conneaut, Ohio to Erie, Pennsylvania, S. J. Williams, E. P. Meisburger, D. A. Prins, CERC technical publication in preparation (1980).

Late Quaternary Peat Deposits on the Atlantic Inner Shelf of the United States, M. E. Field, E. P. Meisburger, E. A. Stanley, S. J. Williams, *Bulletin of the Geological Society of America*, in press (1979).

Sand Resources on the Inner Continental Shelf of the Cape Fear Region, North Carolina, E. P. Meisburger, *CERC Mescellaneous Report No. 77-11*, Nov. 1977, 20 p.

Reconnaissance Geology of the Inner Continental Shelf, Cape Fear Region, North Carolina, E. P. Meisburger, CERC technical publication in press (1979).

Sediment Distribution, Sand and Gravel Resources, and Geologic Character of Long Island Sound, S. J. Williams, CERC technical publication in preparation (1980).

Sand Resources on the Inner Continental Shelf of the Cape May Region, New Jersey, E. P. Meisburger, S. J. Williams, CERC technical publication in preparation (1980).

Sediments, Shallow Subbottom Structure, and Sand Resources of the Inner Continental Shelf, Central Delmarva Peninsula, M. E. Field, CERC technical publication in press (1979).

312-09762-410-00

DATA COLLECTION OF LITTORAL MATERIALS AND FORCES

(*c*) J. R. Weggel, Chief, Evaluation Branch, Engineering Development Division.
(*d*) Field investigation; applied research.
(*e*) Volunteer personnel use Littoral Environment Observation (LEO) techniques to measure basic forces and response elements in the nearshore beach zone. At each site daily observations are made of breaking wave height, period, and direction, type or character of breakers, longshore current velocity, wind speed and direction, foreshore slope, and rip current and cusp spacing. Monthly sand samples are analyzed to provide beach sediment characteristics. Dry beach profiles are made weekly. Where possible, a multitude of sites are established in cooperative efforts (between State and local agencies and the local Corps of Engineers District Office), which continue daily data collection for several years. Computer compatible formated data are processed, collated and studied for long-term characteristics and trends. In addition to LEO other data collection efforts for the Texas Gulf Coast, Lake Michigan, northern and southern coast of California, and coast of Hawaii, Corps of Engineers District have been involved in procurance of profile data, sand samples, wave data, and aerial photography. Objective is to procure and develop data that will be of use in planning and designing coastal projects.
(*g*) Cooperative LEO data collection efforts have been or are continued in the following coastal regions: southern California, (8 sites, active), northern California (25 sites, inactive), Michigan (9 sites, active), Wisconsin, Indiana, Illinois (15 sites, inactive), Oregon (21 sites, active), Washington (4 sites, active), Florida (8 sites, active), Pennsylvania (2 sites, active), Georgia (11 sites, active), South Carolina (7 sites, active), Minnesota (1 site, active), Massachusetts (2 sites, active), and Texas (3 sites, active pilot program). Individual research efforts are not discouraged and volunteer efforts have been or are continued in Massachusetts, Virginia, North Carolina, Florida, Texas, Southern California, Pennsylvania, and Hawaii. Other data collection in Texas, Lake Michigan, northern and southern California, and Hawaii have been terminated and final reports are in preparation by Corps District Offices following completion of data analysis.
(*h*) **Visual Surf Observations/Marineland Experiment,** C. Schneider, *Proc. Coastal Sediments '77* **II**, ASCE, 1977, p. 1086-1100.

312-10649-420-00

SURF ZONE WAVE STATISTICS

(*c*) Michael G. Mattie, Physicist, Coastal Oceanography Branch, Research Division.
(*d*) Field investigation, applied research.
(*e*) An array of wave gages will be installed along the pier portion of the Field Research Facility at Duck, and wave records will be obtained from these. Photography and radar imagery will be used to obtain two-dimensional geometry of the wave field. Data collected will be analyzed statistically to determine wave statistics at the gaging points, the change in these statistics along the pier, and the relation of these statistics to a gage in deeper water at the end of the pier. Data will be used to evaluate theoretical concepts of the modification of waves in shallow water, and their transformation into surf and through the surf zone. This work will provide a description of the statistics in the surf zone and the relation of these statistics to those normally available for engineering design.

312-10650-700-00

RADAR IMAGING OF WAVES

(*c*) Michael G. Mattie, Coastal Oceanography Branch, Research Division.
(*d*) Field investigation, development.
(*e*) The project will determine and develop the optimum procedure for collecting wave direction information using a commercially available, shore based marine radar. The PPI scope shows an image of the waves, which is photographed for later interpretation to provide wave direction and length information. The radar system is automated so that climatology of wave direction can be obtained. Automated image analysis techniques, which are based on digital and optical Fourier Transforms, are also being developed. The video radar return is being examined to determine if an empirical relation between wave height and radar return amplitude can be found.
(*g*) A prototype automated radar system has been built and successfully operated in the field, providing useful wave direction information. Comparisons of data collected during the West Coast Experiment in March 1977 show agreement between the wave direction measurements of the CERC radar system and those obtained by several different measurement techniques, including aerial photos, pressure array, and SAR. The radar system has been installed at the CERC Field Research Facility at Duck, N.C. where it has provided useful data in support of coastal studies and SEASAT validation tests. Digital two-dimensional Fourier Transforms have been obtained for selected radar images providing more information on the nature of the coastal wave field than is easily available through manual analysis.
(*h*) **The Use of Imaging Radar in Studying Ocean Waves,** M. G. Mattie, D. L. Harris, *Proc. 16th Coastal Engrg. Conf.*, ASCE, Sept. 1978.

Ocean Wave Detection and Direction Measurements with Microwave Radars, P. G. Teleki, R. A. Shuckman, W. E. Brown, W. McLeish, D. Ross, M. Mattie, *Proc. Oceans '78*, Marine Technology Society, Sept. 1978.

A System For Using Radar to Record Wave Direction, M. G. Mattie, D. L. Harris, CERC technical report in press, 1979.

312-10651-420-00

WAVE DATA ANALYSIS TECHNIQUES FOR DESIGN

(*c*) E. F. Thompson, Coastal Oceanography Branch, Research Division.
(*d*) Investigation of field data; applied research.
(*e*) Field wave measurements will be used to tabulate occurrences of hazardous individual wave conditions during a variety of sea states and to develop general characteristics and probabilities of hazardous conditions. New analysis procedures which can identify two or more distinct wave trains without presenting the full complexity of the wave spectrum and which provide more information about wave shape than can be obtained from wave spectra will be developed. The usefulness of the developed procedures will be evaluated. Variation of wave characteristics with water depths will be determined with field wave data.
(*g*) High energy wave spectra and summaries of all spectra have been generated for up to 1 year of data from each of 11 coastal gages. Summaries include mean spectra for common combinations of significant height and peak spectral period. Parameters summarized include number of major spectral peaks, spectral peakedness parameter, and third and fourth moments of the normalized distribution function of sea surface elevations. Multiple peaked spectra are common at all locations.

312-10652-420-00

GREAT LAKES WAVE HINDCASTING TECHNIQUES

(c) E. F. Thompson, Coastal Oceanography Branch, Research Division.
(d) Field investigation; applied research.
(e) Because wind wave generation in the Great Lakes is complicated by restricted fetches, shallow water, and variable wind field structure due to air-water temperature differences, existing wave hindcasting techniques can be properly evaluated and modified only by comparing their results to wave gage measurements.
To provide data for evaluating existing hindcasting techniques, pressure and buoy wave gages have been operated in the Great Lakes.
(g) Wave gage data have been collected in lakes Erie and Michigan during fall 1975-6. The data, in both digital and pen and ink strip chart form, have been analzyed. They are now being used to evaluate significant wave height, period, and energy spectrum produced by two operational numerical Great Lakes wave models. The models were developed at the U.S. Army Engineer Waterways Experiment Station and the National Weather Service Techniques Development Laboratory.
(h) **An Evaluation of Two Great Lakes Wave Models,** E. F. Thompson, *Technical Report No. 78-1*, U.S. Army Coastal Engineering Research Center, Oct. 1978.

312-10653-720-00

DEVELOPMENT OF A FIELD RESEARCH FACILITY AT DUCK, NORTH CAROLINA

(c) C. Hare, Acting Chief, Research Support Division.
(d) Field investigations of coastal phenomena.
(e) The Coastal Engineering Research Center (CERC) Field Research Facility (FRF) currently under construction at Duck, North Carolina, will include a 3,300 foot section of the barrier island, a 1,800 foot concrete pier spanning the dunes, beach and surf zone out to a 20 foot (MSL) water depth, a laboratory building, and an instrumented research vehicle to operate on the pier. The facility will provide a permanent field base of operations for carrying out physical and biological studies of an oceanfront site and nearshore area as well as nearby sounds, bays, and barrier islands. The facility will also allow a means of correlating small scale coastal engineering laboratory test results with actual prototype results. Continuous data on coastal phenomena (such as waves, currents, tides, and beach changes) will be monitored across the full width of the surf zone during all weather conditions including severe storms. The ensuing information will result in improved methods for predicting storm damage and in improved designs for restoration and protection of eroded beaches and fragile coastal areas.
(g) The 1800 foot concrete pier is in operation and an active environmental data collection program is underway. Completion of the laboratories is anticipated by end of 1979; and the research vehicle during 1980.

312-10654-430-00

OFFSHORE BREAKWATERS FOR SHORE STABILIZATION

(c) R. M. Sorensen, Chief, Coastal Structures Branch, Research Division.
(d) Experimental, applied research.
(e) This study will investigate the use of relatively low crested segmented offshore breakwaters for shore stabilization. The purpose is to determine the influence of crest elevation and width of breakwaters as well as their position and spacing on wave characteristics in the lee in order to evaluate the potential of offshore breakwaters to reduce shore erosion. Two- and three-dimensional wave tank tests will be conducted. The three-dimensional tests will also investigate current patterns, and segmented breakwater location and spacing factors.
(g) A literature review and laboratory testing program of measuring wave transmission and reflection of breakwaters has been completed.
(h) **Effect of Breakwaters on Waves: Laboratory Tests of Wave Transmission by Overtopping,** W. N Seelig, *Proc. ASCE Coastal Structures 79 Conference*, Mar. 1979.

312-10655-410-00

NUMERICAL PREDICTION OF SHORELINE EVOLUTION

(c) J. R. Weggel, Chief Evaluation Branch, Engineering Development Division.
(d) Theoretical, basic research.
(e) The study was initiated in CY 76 to investigate the feasibility of developing a numerical model that would predict the response of a shoreline to changes in wave energy acting on it. Initial conclusions are that an approximate model suitable for use in planning studies can be developed that will provide estimates of the effects of various coastal structures on adjacent shorelines. A detailed literature survey of publications relating to mathematical prediction of shoreline evaluation is planned. Contract effort has resulted in a preliminary model that is being expanded and tested.
(g) Current efforts are being directed toward the development of a numerical computer model based on equations for longshore sediment transport and the mass balance equation for the sediment. The eventual product will be a computer program that will permit preconstruction estimates of the effects of proposed coastal structures, the interaction among several coastal structures along a shoreline and method for estimating the damages attributable to the construction of a given navigation project.

312-10656-430-00

WEIR JETTY STUDY

(c) J. R. Weggel, Chief, Evaluation Branch, Engineering Development Division.
(d) Experimental, applied research, development.
(e) The three-phase research program will include two series of laboratory experiments and a field measurement program. A series of movable-bed laboratory tests will endeavor to quantify the distribution of sediment transport across a weir jetty for various wave and tidal flow conditions. A second series of tests with a fixed-bed model will establish the hydraulic conditions that can be expected at a weir jetty in different tidal environments and for different geometric configurations. The field measurement program will measure the distribution of sediment transport over a full-scale weir section by mounting sediment traps at various locations along a weir section to determine the transport rate at that section.
(g) Expected output from the program will permit designers to use the empirical data in an integration procedure to evaluate proposed weir jetty designs and to establish weir crest elevation, orientation and length.

312-11439-420-00

WAVE TRANSFORMATION STUDY

(c) J. M. Hubertz, Oceanography Branch, Research Division.
(d) Theoretical and experimental applied research with field data collection.
(e) Two-dimensional numerical models which predict the transformation of a wave field due to various processes are being investigated. Field data is being collected from a research pier and at offshore points for comparison to model results. Resulting models will be used to predict wave conditions near the coast for design purposes.
(g) Some field measurements of wave conditions are available.

312-11440-420-00

MEASUREMENT OF WAVE TRANSFORMATION IN SHALLOW WATER

(c) M. G. Mattie, Coastal Oceanography Branch, Research Division.
(d) Field investigation, applied research.
(e) An array of wave gages has been installed along the pier portion of the Field Research Facility at Duck, N.C., and

wave records are obtained from these. Photography and radar imagery are used to obtain two-dimensional geometry of the wave field. Data collected will be analyzed statistically to determine wave statistics at the gaging points, the change in these statistics along the pier, and the relation of these statistics to a gage in deeper water at the end of the pier. Data will be used to evaluate theoretical concepts of the modification of waves in shallow water, and their transformation into surf and through the surf zone. This work will provide a description of the statistics in the surf zone and the relation of these statistics to those normally available for engineering design.

(*g*) The gage system has been installed and a large quantity of wave data from several locations through the surf zone and for a variety of wave conditions has been collected. Preliminary analyses show spectra which have significant temporal variability as well as a complicated transformation as the waves approach the shore.

312-11441-410-00

INLET HYDRAULICS MEASUREMENT AND PREDICTION

(*c*) R. M. Sorensen, Chief, Coastal Structures Branch, Research Division.
(*d*) Field investigation, applied research.
(*e*) The purpose of this study is to determine the hydraulic characteristics of a tidal inlet and define spatial and temporal variations in the hydraulic roughness of the inlet channels over a tidal cycle. Data to be collected includes water levels and velocity measurements and hydrographic surveys at an inlet to be chosen. The results will be used to improve the predictive capabilities of numerical models of tidal inlet hydraulics.
(*g*) Planning for field investigation and literature review are in progress.

312-11442-430-00

RUBBLE STRUCTURES IN THE SURF ZONE

(*c*) R. M. Sorensen, Chief, Coastal Structures Branch, Research Division.
(*d*) Experimental, applied research.
(*e*) The objective is to produce design criteria for the stability of one and two armor layer, low crested structures subjected to breaking waves in the surf zone. Test of rubble mound structures constructed on a sand base will be conducted at prototype scale using CERC's Large Wave Tank. Tests will be made to determine the extent of toe scour due to breaking waves, determine the stability of a bedding armor layer used to prevent toe scour during construction, determine the stability of a typical jetty toe design in the presence of breaking waves and to determine the stability of a low profile structure subject to non-overtopping and overtopping breaking waves.

DEPARTMENT OF THE ARMY, DIVISION HYDRAULIC LABORATORY, NORTH PACIFIC DIVISION, CORPS OF ENGINEERS, Bonneville, Oreg. 97008. Peter M. Smith, Director.

313-05070-350-13

MODEL STUDY OF SPILLWAY FOR DWORSHAK DAM, NORTH FORK CLEARWATER RIVER, IDAHO

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Dworshak Dam, on the North Fork of Clearwater River will furnish 400,000 kW of power from three units (initial installation) and, ultimately, 1,060,000 kW from six units. The spillway consists of two 50-foot wide bays, with crest at elevation 1545, a chute, and a 114-foot wide, 271-foot long stilling basin at elevation 931. Three 9- by 12.5-foot regulating outlets, upstream from the tainter valves, and 11 by 17 feet downstream from valves, discharge on the spillway chute. Total capacity of the spillway and regulating outlets is 221,000 cfs at pool elevation 1604.9. Approximately 1.6 miles of river channel and pertinent overbank topography were reproduced in a 1:50-scale model to study the cofferdam and diversion tunnel. A section of forebay, the spillway, regulating outlets, stilling basin, powerhouse, tailrace, and exit channel were reproduced to determine hydraulic characteristics of these elements.
(*f*) Tests completed; final report in preparation.
(*g*) See 1970 issue.

313-05071-350-13

GENERAL MODEL STUDY OF LOWER GRANITE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Lower Granite Dam, at Snake River mile 107.5, is 37.2 miles upstream from Little Goose Dam. The 8-bay spillway, with 50- by 60.5-foot control gates (tainter) and the 498-foot wide, 167-foot long nonbaffled stilling basin are designed for a maximum discharge of 850,000 cfs. The 6-unit powerhouse will have a capacity of 810,000 kW; initial installation 405,000 kW from three units. The 86- by 675-foot navigation lock will have a maximum single lift of 105 feet. Fish facilities include a powerhouse collection system, three pumps for additional attraction flow (2550 cfs) and one 20-foot wide fish ladder with floor slope of 1 on 10. A 1:100-scale general model reproduced the riverbed and pertinent overbank topography between Snake River miles 106.1 and 108.9 and successive phases of construction. Construction stages, powerhouse tailrace limits and depths, navigation lock approaches, flow conditions affecting fish passage, and project operations were to be studied in the model.
(*f*) Tests completed; final report in preparation.
(*g*) The first-step cofferdam and diversion channel were satisfactory after the channel entrance was modified and rock groins to aid fish migrations were added. Embankment and excavation limits for construction phases were determined. The effects of several stages of erosion downstream from the original stilling basin were investigated, and an improved basin design was developed with estimated maximum erosion in the tailrace. Satisfactory energy dissipation was obtained with the stilling basin raised 4 ft and a 9-ft end sill (originally 11 ft high). An undesirable eddy existed between the north fishway entrance and the navigation lock wall. Several combinations of walls, fills, and training wall extensions were tried in efforts to develop satisfactory conditions at the north fishway entrance. Development of modifications to reduce nitrogen supersaturation caused by spillway discharges was begun. Preliminary results indicate that 12.5-ft wide horizontal deflectors on the spillway ogee will produce stable "skimming flow" in the stilling basin for river flows up to the 10-year flood, and required energy dissipation will occur at high flows; see also 313-07120.

313-05315-350-00

MODEL STUDY OF REGULATING OUTLETS FOR DWORSHAK DAM, NORTH FORK CLEARWATER RIVER, IDAHO

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-05070 for description of project. The three regulating outlets, with intakes at elevation 1350, will operate under heads of from 95 feet at minimum pool elevation 1445 to 254.9 feet at maximum pool elevation 1604.9. Total outlet capacity will be 40,000 cfs at pool elevation 1604.9. Pressures, flow conditions, and discharge relationships were observed in a 1:25-scale sectional model that reproduced a portion of the forebay, the right conduit, and a section of the spillway chute. The purpose of the study was to check the adequacy of the original design and to develop revisions if necessary.
(*f*) Tests completed; final report in preparation.
(*g*) Four designs for a bellmouthed intake were studied. See 1970 issue for details.

313-05317-330-13

MODEL STUDY OF COLUMBIA RIVER, OAK POINT TO VANCOUVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) The project will increase the navigation channel width from 500 feet to 600 feet and the depth from 35 to 40 feet between Columbia River miles 52 to 109 and from the mouth of Willamette River to Portland, Oregon. Project depths and widths will be maintained by a system of pile dikes and by dredging. Five separate movable-bed models with 1:300 horizontal and 1:100 vertical scales will be required to cover improvements in the Columbia River. The models will be used initially to check plans for constructing and maintaining the 40-foot channel. Later the models will be used to check operation and maintenance activities and new construction. The first two models include river miles 53 to 65 and 64 to 78, respectively. Work on the remaining three models has not begun.
(*f*) Scheduled tests of river miles 53 to 78 completed; final report in preparation.
(*g*) Shoaling indexes, based on results with an uncontrolled 40-foot deep navigation channel, were determined for each improvement plan tested in the models. Satisfactory plans are being developed for all problem reaches covered by both models. Alternative proposals, which would be more acceptable to local interests in the Longview-Rainier area (mile 66), were tested and the benefits of these plans were determined.

313-07107-350-13

MODEL STUDY OF SECOND POWERHOUSE FOR BONNEVILLE DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) The existing project includes an 18-bay spillway with vertical gates lifted by 350-ton gantry cranes, a powerhouse with total rated capacity of 518,000 kW from 10 main units and one station service unit, a navigation lock with net clear dimensions of 76 by 500 feet, and fish facilities on each side of the river. Head on the project varies between 30 and 70 feet. From four to ten additional units are proposed to utilize increased storage and peaking operations at upriver projects. A 1:100-scale fixed-bed model reproduces the existing structures, riverbed, and pertinent overbank topography between river miles 142.2 and 146.8. A remote controlled towboat and tow are used to evaluate the effect of additional power units on navigation. The purpose of the study is to confirm the site chosen for the second powerhouse and to study flow conditions affecting fish passage, navigation, and head on the project.
(*g*) Three structures and excavation plans were investigated. Tests of the recommended plan (with present lock and provision for a future lock on the Oregon shore and an eight-unit powerhouse on the Washington shore) were continued. Tests indicated that 12-ft-long horizontal deflectors at elev. 14 between piers on the spillway ogee will produce stable "skimming flow" in the stilling basin for normal tailwater levels with the present 10-unit powerhouse and spillway flows between 1,000 and 16,000 cfs per bay. This should reduce levels of dissolved nitrogen downstream from the spillway. Spillway operating schedules were developed to provide good conditions for upstream passage of fish. This information was used in 1974 to evaluate the effects on fish passage of prototype deflectors in bays 13, 14, and 15 of the 18-bay spillway. Placement of construction spoil on the floodplain downstream caused an acceptable rise in tailwater of 3 ft at the dam with the maximum probable flood. Alignment of forebay and tailrace channel banks for the new powerhouse for best fish passage was developed. Dispersion of turbidity created by channel excavation was observed.

313-07109-350-13

MODEL STUDY OF INCREASED POOL ELEVATIONS AT SPILLWAY OF CHIEF JOSEPH DAM, COLUMBIA RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) The existing project, located 51 miles below Grand Coulee Dam and 545 miles from the mouth of Columbia River, includes an excavated channel leading to an intake for 27 penstocks, a 20-unit powerhouse (initial installation 16 Francis turbines), and a spillway with nineteen 40-ft-wide bays surmounted by 9-ft-wide piers and 56.2-ft-high tainter gates. The spillway ogee was designed for a head of 41.6 ft on the crest, or 75 percent of the computed maximum total head of 55.4 ft at the project design flow of 1,250,000 cfs. Construction of a third powerhouse at Grand Coulee Dam will require additional storage and power units at Chief Joseph to use the increased flow. Present plans include raising the Chief Joseph pool from existing elevations 946 to maximum elevations 970, or up to 1.7 times the design head. Preliminary data on surge characteristics at the spillway were obtained in an existing spillway model that contained a standard high dam crest and piers with elliptical noses. The most suitable modifications (13-foot thick piers, 36-foot wide bays, gate radius 55 feet, gate trunnions at elevation 920 and 61.83 feet from existing crest axis) were studied in a 1:43.35-scale model. Water-surface elevations at the outlet of a 4-foot diameter relief tunnel in the right training wall were determined for uniform and varied operations of spillway gates during spillway flows of 50,000 to 550,000 cfs (powerhouse discharge 250,000 cfs).
(*f*) Tests completed; final report in preparation.
(*g*) The tests indicated that the original crest and stilling basin would be satisfactory. Surging of flow on higher, narrower spillway gates was severe at large partial gate openings. This unstable periodic surge resulted from the combined effects of structural geometry, large heads, and gate openings required to release desired flows. Surging in the narrow bays was reduced from a maximum of 10.8 feet (pool elevation 961.2 and gates open 35 feet) to 2.8 feet by suppressors that extended 4 feet from the side of each pier above the maximum nappe at free flow. Closing the right spillway gate allowed the relief tunnel to drain until the river discharge exceeded 800,000 cfs. A vertical deflector projecting 2 feet from the training wall just upstream from the relief tunnel outlet would reduce water levels in the tunnel and allow uniform spillway operation for most discharges.

313-07110-350-13

MODEL STUDY OF CONDUIT ENTRANCES FOR DWORSHAK DAM, IDAHO, AND LIBBY DAM, MONTANA

(*b*) U.S. Army Engr. Dist., Walla Walla and Seattle.
(*d*) Experimental; for design.
(*e*) Normal reservoir outflows at Dworshak and Libby Dams will discharge on the respective spillway chutes through conduits that operate under heads up to 250 feet on the regulating valves (tainter). Although conduit dimensions upstream from the valves differ (9 by 12.5 feet at Dworshak and 10 by 17 feet at Libby), the same type of bellmouthed intake will be used at both dams. The tentatively adopted "no-skew" intakes that were developed during the Dworshak conduit model study extended upstream beyond the face of the dam. This would have complicated design and use of unwatering bulkheads. A regulating conduit with streamlined entrance and a portion of forebay were reproduced in a 1:20-scale model for measurements of discharges, pressures, and other data. The purpose of the study was to develop revisions that could be used at Dworshak, Libby, or other projects.
(*f*) Tests completed; final report in preparation.
(*g*) Three designs for short, skewed, bellmouthed entrances for the Dworshak and Libby conduits were tested. Satisfactory plans for both entrances were developed.

(*h*) **Skewed Entrance for High-Head Conduits,** *Engineer Technical Letter No. 111-2-41*, Dept. of the Army, Office of the Chief of Engrs., Washington, D.C., May 1968.

313-07111-850-13

MODEL STUDY OF FISHWAY DIFFUSER FOR DWORSHAK DAM, NORTH FORK CLEARWATER RIVER, IDAHO

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-05070 for description of project. Adult fish will be attracted into a collection channel leading to a holding pool from which they will be transported to a hatchery, to the reservoir, or to another stream. Water for operation of the fish facilities will be pumped from tailwater, and distributed by means of six diffusion chambers into the collection system holding pool, and hopper pool. A typical diffusion chamber and portions of the adjoining supply conduit and collection channel were reproduced in a 1:10-scale model. Flow in the conduit varied from 100 to 480 cfs, diffuser discharge was 60 cfs, and a differential head of 2.5 feet existed between the supply conduit and collection channel. The purposes of the study were to check the adequacy of a typical diffusion chamber and to develop revisions if required.
(*f*) Tests completed; final report in preparation.
(*g*) See 1970 issue.

313-07112-850-13

MODEL STUDY OF HATCHERY JET HEADER FOR DWORSHAK DAM, NORTH FORK CLEARWATER RIVER, IDAHO

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-05070 for description of project. A new type of rearing pond, developed by the U.S. Fish and Wildlife Service, will be adapted for use at the Dworshak fish hatchery. Circulation in each pond will be provided by two jet headers that discharge between 70 and 400 gpm (0.17 to 0.89 cfs). One header, constructed full-scale of aluminum pipe, was attached to an existing water supply, tank, and weir box. The purpose of the study was to determine head-discharge relations and jet velocities for 1-1/4 and 1-inch nozzles.
(*f*) Tests completed; final report in preparation.
(*g*) See 1970 issue.

313-07114-850-13

MODEL STUDY OF REVISIONS FOR FISH LADDERS AT JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) John Day Dam is on the Columbia River 25 miles upstream from The Dalles, Oregon. The 5900-foot-long dam provides 76 miles of slack water for navigation to McNary Dam and 500,000 acre-feet of flood storage. The dam has a 20-bay spillway (2,250,000 cfs), 20-unit powerhouse (16-135,000 kW units installed). 113-foot single lift navigation lock, and two fish ladders. Based on tests in a previous model (3578 in 1970 issue of HRUSC) an 18-pool submerged orifice regulating section was developed for the north fish ladder. The design incorporated a horizontal counting station between the fixed weir and regulating sections. A similar type of regulating section was used in the south fish ladder; a vertical-board-type counting station was located in the sloping portion of the ladder. Difficulties with passage of fish (especially shad) led to studies of vertical-slot regulating sections for both the north and south ladders. A 1:10-scale model was used for tests of 23 pools of the north fish ladder and then the exit, regulating section, auxiliary water diffusion chamber, fish counting station, and eight pools downstream from the counting station. The model was used to check proposed revisions and to develop modifications to them. Similar tests were made for the south ladder where the design differed from the north ladder.
(*f*) Tests completed; final report in preparation.
(*g*) A new, very effective design of vertical-slot regulating section incorporating twice the usual number of pools with a maximum water surface drop of 6 in. per pool was developed. After full-scale test of six pools with fish in the National Marine Fisheries Service Laboratory, North Bonneville, Wash., the south ladder at John Day was modified to this design. After a full season of very successful fish passage, the north ladder also was revised.

313-07117-350-13

MODEL STUDY OF SPILLWAY FOR LIBBY DAM, KOOTENAI RIVER, MONTANA

(*b*) U.S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) Libby Dam, at Kootenai River mile 219, 17 miles upstream from Libby, Montana, will include a spillway with two 48-ft wide bays with crests at elevation 2405, three 10- by 17-ft regulating outlets, and a powerhouse for eight Francis units (ultimate installation 840,000 kW). Three powerhouse units (total capacity 315,000 kW) will be installed initially. At maximum pool elevation 2459, spillway capacity will be 145,000 cfs and total capacity of regulating outlets will be 61,000 cfs. The 116- by 300-ft stilling basin, at elevation 2073, is designed for a maximum spillway discharge of 50,000 cfs. A 1:50-scale model reproduced a portion of the forebay, all hydraulic elements of the spillway and powerhouse, and 1600 ft of exit channel. The initial purpose of the model was to check the adequacy of the spillway, regulating outlets, stilling basin, and excavated outlet channels. The scope of the study was increased to include tests of diversion plans and flow conditions with a powerhouse selective withdrawal structure.
(*f*) Tests completed; final report in preparation.
(*g*) The model tests showed that the original spillway abutments, center pier, chute, and stilling basin were not satisfactory. During development tests, the bulkhead slots and upstream projections of pier and abutments were eliminated and the circular abutments were changed to elliptical. The center pier was narrowed from 24 to 20 ft, and both sides of the pier were tapered. A tapered extension of the center pier was used to reduce undesirable rooster tail in flow down the chute. The original stilling basin was 120 ft wide and 172.8 ft long at elevation 2074, and the basin walls were at elevation 2127. The adopted basin is 116 ft wide, 300 ft long, at elevation 2073, and the sidewalls are at elevation 2142. Sizes of rock needed for riprap in exit areas were determined. Six diversion plans were studied before an acceptable plan was selected. Several types of deflectors to prevent debris from lodging against the legs of a contractor's tower were investigated for flows greater than 50,000 cfs during second-stage construction. The adopted plan consisted of two concrete piers 15 ft high and 87 ft long. Each pier acted as a deflector and later would become part of the mass concrete monolith. Tests of the selective withdrawal structures indicated that overflow bulkheads on the face of the intake must be submerged about 20 feet to supply the turbine unit flow of 5800 cfs at pool elevation 2459. The pier nose shapes were revised and a floating skimmer device was developed to prevent vortex action and air entrainment at intakes of the selective withdrawal structure. Scheduled studies with flow into a single powerhouse unit from a density-stratified reservoir have been completed.
(*h*) **Selective Withdrawal System, Libby Dam, Kootenai River, Montana,** A. G. Nissila, P. M. Smith, *Div. Hydr. Lab. Tech. Rept. No. 125-2*, Dec. 1975.

313-07118-350-13

MODEL STUDY OF OUTLET WORKS FOR LOST CREEK DAM, ROUGE RIVER, OREGON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) Lost Creek Dam on the Rouge River will provide 315,000 acre-feet of usable storage for flood control and other uses and 49,000 kW of electric power. A multiple-use intake

tower with openings at four levels will lead to a 15-foot diameter penstock and to a 12.5-foot diameter regulating outlet. A 6- by 12-foot bypass will permit reservoir releases through the penstock when the intake tower is unwatered. The spillway will include three 45-foot bays. Design discharges are as follows: outlets works 9860 cfs at minimum pool elevation 1812, and 11,460 at maximum pool elevation 1872; bypass 2000 cfs; spillway 158,000 cfs. A 1:40-scale model reproduced a portion of forebay, the multiport intake tower, regulating outlet intake valve section, conduit and chute, stilling basin, penstock intake and curve, powerhouse, and a section of downstream channel. Flow conditions and pressures in the tower bypass system were studied in a separate 1:40 scale model. The purposes of the study were to investigate flow conditions and pressures in the intake tower, regulating outlet, and penstock; to measure discharges through the regulating valves and bypass intake; and to check performance of energy dissipator, tailrace, and downstream channel.

(*f*) Tests completed; final report in preparation.

(*g*) Flow conditions and pressures at the intakes of both models were satisfactory. An 80 ft long section of chute walls of original design was overtopped as much as 3 ft during the chute design discharge of 12,000 cfs. The stilling basin was adequate from a hydraulic standpoint. However, the air entrainment and resulting nitrogen supersaturation downstream from this type of basin were not acceptable. Tests indicated that an alternative design with revised chute and a 30-degree, 50-ft radius flip bucket would be satisfactory. Wave suppressors 4 ft wide by 8 ft long were required on the chute walls to prevent overtopping.

313-07120-350-13

MODEL STUDY OF SPILLWAY FOR LOWER GRANITE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) See 313-05071 for description of project. The 1:42.47-scale model included a 3-bay section of the 8-bay spillway, stilling basin, and approach channels. The study was expanded to include the hydraulic characteristics of horizontal deflectors with and without dentates on the spillway ogee. These devices may reduce nitrogen supersaturation by causing air entrained by small to moderate spillway discharges to remain near the water surface in the stilling basin. The purposes of the model are to check designs for the spillway crest, piers and abutments, chute, stilling basin, excavated channel, deflectors on the spillway ogee, and to develop revisions if required.

(*f*) Tests completed; final report in preparation.

(*g*) No revisions of the original crest and piers were required. Discharge rating curves for both free and gated flows were obtained. Satisfactory agreement was not obtained between tailwater-jump curves measured in the spillway model and in the general model (study 5071). Return flow into the stilling basin from the powerhouse tailrace and expansion of flow along the lower lock guard wall were responsible for the differences. The final design for the stilling basin will be based on tests in the general model. Tests in the spillway and general models indicate that a 12.5-foot wide horizontal deflector at elevation 630 (crest elevation 681) will produce desired stable, shallowly aerated, "skimming flow" in the stilling basin for spillway discharge 10,000 cfs per bay. Skimming action was improved by adding three rows of 1.8- by 2.6-ft dentates to ogee and deflector. Pressures on the deflector were positive.. Cavitation may develop on the dentates. Use of deflectors and dentates does not reduce the energy dissipating capability of the stilling basin at high flows.

313-07121-330-13

MODEL STUDY OF NAVIGATION LOCK FOR LOWER GRANITE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.

(*d*) Experimental for design.

(*e*) See 313-05071 for description of project. In the unusual hydraulic system, a central junction chamber connects both longitudinal culverts to eight symmetrically-located longitudinal port manifolds (four upstream and four downstream) in the floor of the lock. There are six pairs of ports in each manifold. A 1:25-scale model reproduced a portion of the forebay and floating guide wall, the hydraulic system, the lock chamber, and portions of exit areas and downstream approach. The purposes of the investigation were to check the adequacy of the proposed design and to develop modifications if required.

(*f*) Tests completed; final report in preparation.

(*g*) See 1970 issue.

313-08442-850-13

FISH HATCHERY AERATOR AND DEAERATOR TESTS

(*b*) U.S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) Filtered water, aerated, deaerated, and temperature regulated, will be recirculated through systems of headers and nozzles into rearing and holding ponds of several fish hatcheries that are being installed by the Corps of Engineers. Each pair of nozzles is designed to discharge 250 gpm (125 gpm per nozzle). One bank of 28 pairs of aerator nozzles (total discharge 7000 gpm) will be supplied by a 16-inch header pipe. Another bank of 16 nozzles (4000 gpm) will be supplied by a 12-inch header. Two banks of deaerators will be supplied by 6- and 8-inch headers (respective discharges 750 and 1000 gpm). Equal pressures are desired in both sets of headers. The purpose of the investigation was to calibrate aerator and deaerator systems of commercial black iron and PVC plastic pipe.

(*f*) Tests completed; final report in preparation.

(*g*) Pressures, discharges, and air demands were measured for four sizes of aerator pipe. Pressures and discharges were determined for four sizes of deaerator pipe.

313-08443-350-13

MODEL TESTS OF RELIEF PANEL FOR SELECTIVE WITHDRAWAL GATES AT DWORSHAK DAM, NORTH FORK CLEARWATER RIVER, IDAHO

(*b*) U.S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) See 313-05070 for description of project. Selector gates of the multi-level power intakes will have 90 pressure relief panels per power intake to protect the gates against failure from internal waterhammer or excessive differential pressures caused by misoperation of the gates or power units. The panels will consist of butterfly valves mounted on torsion bars. A 1:5-scale model was used to determine torque on the shaft of a 1- by 4-foot panel and discharge for various openings under differential heads of 3 to 20 feet. The data were needed to verify and supplement design computation.

(*f*) Tests completed.

(*g*) Torque and discharge were measured for panel openings of 10, 20, 30, 40, and 45 degrees and heads of approximately 3 to 20 feet. Torque decreased with panel opening until a negative value was reached at an opening of 47 degrees. The maximum torque, 1869 foot-pounds, was measured at a differential head of 18.37 feet and a panel opening of 10 degrees.

313-08444-350-13

MODEL STUDY OF POWERHOUSE SKELETON UNIT FOR LOWER GRANITE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) See 313-05071 for description of project. A 1:40-scale model reproduced a proposed powerhouse skeleton unit and sections of approach and exit channel. The study was to determine the maximum discharge as limited structurally that could be released through a unit without entraining air and causing or increasing nitrogen supersaturation of flow passing the project, and the best method of controlling the discharge.

(*f*) Tests completed; final report in preparation.
(*g*) Initially, the operating gates were tested as flow controls. Then the gates in combination with stoplogs in the gate and intake slots were investigated. From these studies, a bulkhead with slots or converging tubes was developed for prototype tests in a similar unit at Little Goose Dam during the spring freshet in 1971. Slots in the top seven rows were 4 inches high; the lower eight slots were 6 inches high (area 95 sq. ft.). The slot tubes converged on slopes of 1 on 4.27 and 1 on 4.78, respectively. The skeleton unit discharged 21,200 cfs (discharge coefficient 0.932) under 99 feet of head between forebay and tailwater. Positive pressures were measured within the converging tubes and on the piers at the operating gate slots. Flow conditions within the skeleton bay were turbulent but satisfactory. Full-height, 12-inch deflectors attached to the left faces of intake piers reduced upwelling in the left downstream corner of the bay. Measurements at Little Goose Dam showed no increase in nitrogen supersaturation in flow downstream from a bulkhead skeleton unit. Discharges were measured and flow conditions were determined with and without slotted bulkheads upstream from partially-completed units with scroll case and wicket gates installed.

313-08445-350-13

MODEL STUDY OF POWERHOUSE SKELETON UNIT FOR ICE HARBOR DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Ice Harbor Dam is located on the Snake River 9.7 miles upstream from the Columbia River. Principal features include a six-unit powerhouse, an eight-bay spillway, a 103-foot single lift navigation lock, and two fish ladders. The study was made to develp a satisfactory design for slotted bulkheads which would allow passage of the maximum flow through a skeleton unit without entraining air. Entrained air would cause or increase nitrogen supersaturation of flow passing the project. A 1:40-scale model reproduced an existing powerhouse skeleton unit and sections of approach and exit channel.
(*f*) Tests completed; final report in preparation.
(*g*) The original bulkhead design, which was based on the design developed in the Lower Granite skeleton unit model (313-08444), was not satisfactory when tested in the Ice Harbor model because of submergence differences. An alternative plan with three 8-inch, four 6-inch, and five 4-inch slots (bottom to top, area 84.5 sq. ft.), provided satisfactory control of turbulence and aeration and a discharge of 19,200 cfs per unit. Nearly unrestricted movement of operating gates when activating or deactivating the skeleton unit was possible.

313-08446-350-13

MODEL STUDY OF ORIFICE BULKHEADS FOR POWERHOUSE SKELETON UNITS AT JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) The purpose of the study was to develop a design for orifices in bulkheads to control discharges through skeleton powerhouse units without air entrainment that would increase nitrogen supersaturation below the dam. These skeleton units differ from those tested for other projects in that more concrete was added to the turbine bays. A final stage skeleton unit and sections of approach and discharge channels were tested in a 1:40-scale model.
(*f*) Completed; final report in preparation.
(*g*) Modifications tested included a temporary roof over the turbine bay, a partition on the intake roofs, and slotted bulkheads in the intake bays. Tests were made on four plans with a bulkhead in all three intakes and on seven plans with a bulkhead in the center intake only (no flow through the other intakes). Although conditions with the temporary roof and three bulkheads were acceptable, these modifications would be very costly. With a single bulkhead, heads on interior walls, pressures on the bulkhead, and air entrainment were excessive.

313-08447-350-13

MODEL STUDY OF SPILLWAY FOR LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Develop spillway flow deflectors that will produce stable "skimming flow" in the stilling basin, reduce deep air penetration and nitrogen supersaturation, and still allow good energy dissipation at high discharges. A three-bay section of upstream approach, spillway, stilling basin, and downstream channel were reproduced in a 1:42.47-scale model.
(*f*) Completed; final report in preparation.
(*g*) Air pentration, flow directions and flow stability in the stilling basin were observed with and without deflectors on the spillway chute. Without deflectors, flows of 5,175 to 15,000 cfs per bay carried large amounts of entrained air to the invert of the stilling basin. Three lengths of deflectors (15, 12.5, and 10 ft) were tested for discharges of 2,560 to 106,250 cfs per bay. The best design, a 12.5-ft deflector at elevation 434, provided stable skimming flow for river discharges to 251,000 cfs (15,000 cfs per bay with flow through six powerhouse units). These deflectors did not reduce stilling basin capacity at higher flows. Three rows of 1.8-ft-wide by 2.6-ft-high dentates located on and just upstream from the deflectors further reduced air penetration and stabilized flow in the stilling basin. Tests in one prototype bay in 1972 indicated that the deflector did reduce nitrogen supersaturation, but areas of concrete just downstream from the dentates were severely damaged by cavitation and debris. Additional tests, without dentates, were made in a general spillway model (see separate report).

313-09341-350-13

MODEL STUDY OF SPILLWAY DEFLECTORS FOR ICE HARBOR DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-08445 for description of project. The purpose of the study was to develop deflectors on the spillway ogee to reduce deep air entrainment in the stilling basin and nitrogen supersaturation downstream from the spillway. A three-bay section of upstream approach, spillway, and exit channel were reproduced in a 1:40-scale model.
(*f*) Tests completed; final report in preparation.
(*g*) Spillway discharges of 17,500 cfs or less per bay (river discharge 250,000 cfs or less) were of primary concern because these flows occur during the most important runs of fish. The best overall reduction in depth and quantity of air penetration was obtained with 12.5-ft-wide by 50-ft-long deflectors at elevation 336. With these deflectors, surging occurred in the stilling basin for spillway flows of 13,000 to 25,000 cfs per bay. Additional tests will be made in a 1:50-scale general spillway model.

313-09342-350-00

MODEL STUDY TO REDUCE NITROGEN SUPERSATURATION, LIBBY REREGULATING DAM, KOOTENAI RIVER, MONTANA

(*b*) U.S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) See 313-09345 for location of project. The study was made to develop a spillway structure that would reduce dissolved nitrogen in supersaturated water flowing over it to approximately 100 percent saturation.
(*f*) Completed; final report in preparation.
(*g*) In a full-scale test facility dissolved nitrogen was removed from supersaturated water as it was highly aerated and agitated while passing down a baffled chute. Three shapes and two sizes of baffles and two chute slopes were tested. A special baffle shape was developed. In a 25.11-scale model a spillway with tainter gates, a stilling area, and a chute with the special baffles was developed. The spillway would pass 8,500 cfs per 50-foot bay with the hydraulics

developed in the test facility and pass a probable maximum flood flow of 42,000 cfs per bay satisfactorily. Pressures on the baffles were measured to determine hydraulic loading.

313-09344-350-13

MODEL STUDY TO REDUCE NITROGEN SUPERSATURATION, LIBBY DAM, KOOTENAI RIVER, MONTANA

(*b*) U.S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) See 313-07117 for description of project. The purpose of the study was to develop flow deflectors or other devices on the sluices and spillway that will allow discharge through the stilling basin with a minimum of air entrainment and nitrogen supersaturation downstream from the project. The spillway, regulating outlets, stilling basin, and portions of the forebay and tailrace were reproduced in a 1:50-scale model.
(*f*) Completed; final report in preparation.
(*g*) Flip buckets and deflectors below the sluice outlets and slotted bulkheads in the sluice intakes were investigated singly and in combination. Flow conditions with three short 10-degree deflectors were good for a sluice flow of 10,000 cfs and unsatisfactory at discharges higher than 20,000 cfs. None of the plans was adequate for the initial period of no power flow. The tests were discontinued.

313-09345-350-00

MODEL STUDY OF LIBBY REREGULATING DAM, KOOTENAI RIVER, MONTANA

(*b*) U.S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) Flow conditions at the dam during construction and after completion are to be studied in a 1:80-scale model. The model reproduces the Kootenai River channel and pertient overbank topography for one upstream and two miles downstream for the dam site. All pertinent interim and permanent structures will be reproduced. The project design and probable maximum flood discharges for the project are 42,000 and 210,000 cfs. The dam will be near Libby, Montana, 11 miles below the existing Libby Dam.
(*g*) Shoofly on left bank at construction site had negligible effect on river flow. Proposed excavation of approach and tailrace channel of combined powerhouse-spillway could be reduced. Length of proposed downstream training walls has been reduced.

313-09346-350-13

MODEL STUDY OF FALSE WEIR AND FISH LADDER, CHARLES RIVER, MASSACHUSETTS

(*b*) U.S. Army Engr. Division, New England.
(*e*) To check the adequacy of proposed designs for the false weir and slot-type fishway and to develop improved designs if necessary. A 1:4-scale model reproduced the false weir, inflow pipe and part of the first pool downstream from the false weir. A 1:8-scale model included the false weir, 29-pool fish ladder, diffusion chambers for attraction flow, and a section of downstream approach.
(*f*) Completed.
(*g*) The ladder developed in the model study has 29 pools that are connected by vertical slots that provide fish passage between the entrance and a false weir with exit chute to the upstream basin. Velocities in the slots ranged from 1.1 to 7.2 fps. No upwelling that might attract or trap fish occurred along walls or in corners. Velocities over the false weir were between 4.1 and 4.9 fps, downstream discharge of the weir was 14 to 15 cfs, and discharge to the chute was 1.23 to 2.48 cfs. Attraction flow from the entrance penetrated 50 to 60 ft into tailwater.
(*h*) Fish Ladder for Charles River Dam, Charles River, Massachusetts, *Div. Hydr. Lab., Tech. Rept. No. 157-1*, Dec. 1977.

313-09347-350-00

MODEL STUDY OF OUTLET WORKS FOR ELK CREEK DAM, ROUGE RIVER BASIN, OREGON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) The project will be located on Elk Creek, 1.7 miles upstream from the Rouge River and 27 miles north of Medford, Oregon. The dam will be a 238-foot-high rockfill embankment with a concrete gravity spillway and a twin-conduit outlet tunnel with a flip bucket dissipator. The tunnel is to pass a discharge of 7,200 cfs. The outflow of the flip bucket, the size of the plunge pool, and an adult fish collection facility entrance were studied in a 1:40-scale model.
(*f*) Tests completed; final report in preparation. Tests were terminated when design of the project was deferred because of environment problems.
(*g*) The outflow of the flip bucket was satisfactory, and the plunge pool was a minimum size for satisfactory velocities along the excavated sides. The proposed fish collection entrance at the side of flip bucket was not satisfactory; reverse flow occurred in the approach path with some modes of outlet operation. Preliminary tests indicated an entrance in the upstream corner of the plunge pool would be satisfactory; however, testing was terminated before a complete study was made.

313-09348-350-00

GENERAL MODEL STUDY OF CHIEF JOSEPH DAM, COLUMBIA RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) See 313-07109 for description of project. The study was made to determine the effects of spillway deflectors and ultimate 27-unit powerhouse on flow conditions in the tailrace. A section of forebay, the 19-bay spillway with piers and gates for the pool raised 10 ft to elevation 956 (bays 36 ft wide instead of as-built 40-ft bays), downstream side of 27-unit powerhouse, and tailrace to the mouth of Foster Creek were reproduced in a 1:72-scale model.
(*f*) Tests completed; final report in preparation.
(*g*) Velocities, wave heights, water-surface elevations, and overall flow conditions were observed with uniform and nonuniform spillway gate openings. River discharges of 190,000 to 1,200,000 cfs and operation of 0, 9, 18, and 27 powerhouse units were studied. With 12.5-ft-wide deflectors at elevation 775 (see separate report), wave rideup along the banks and wave heights at the powerhouse created by the deflectors was reduced by nonuniform openings of the spillway gates.

313-09349-350-13

MODEL STUDY OF SPILLWAY DEFLECTORS FOR CHIEF JOSEPH DAM, COLUMBIA RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) See 313-07109 for description of project. The purpose of the study was to develop a flow deflector to produce stable "skimming flow" instead of plunging flow in the stilling basin, thereby reducing nitrogen supersaturation downstream from the spillway. A four-bay, 1:43.35-scale sectional model reproduced the existing stilling basin, exit channel, and spillway agee. The piers and gates were for the raised pool, elevation 956, with 36-ft-wide bays, rather than with as-built 40-ft bays.
(*f*) Tests completed; final report in preparation.
(*g*) A 12.5-ft-wide deflector at elevation 775 on the spillway chute provided the best overall performance. Skimming flow existed up to 14,000 cfs per bay with tailwater for 27-unit powerhouse operation, 10,000 cfs with 18-unit operation, and 6,500 cfs per bay with the powerhouse closed. Either surging or plunging flow occurred above these limits. Surging flow may increase wave action along the downstream side of the powerhouse. Deflectors on piers adjacent to ends of spillway were required to minimize

overtopping of training walls. Tests of the entire structure were made in a 1:72-scale model (see separate report).

313-09350-350-13

MODEL STUDY OF SPILLWAY DEFLECTORS FOR LITTLE GOOSE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental, for design.
(*e*) Deflectors on the spillway just below tailwater were developed to reduce deep air entrainment in the outflow and nitrogen supersaturation downstream from the spillway. A three-bay section of upstream approach, spillway, and exit channel were reproduced in a 1:42.47-scale model.
(*f*) Test completed; final report in preparation.
(*g*) Four deflector widths and three elevations were studied, and the width and location that performed best with discharges from 4,700 to 106,250 cfs per bay was selected. Effects of the deflector on flow conditions downstream from the dam, especially on adult fish passage, were studied in a 1:50-scale general spillway model (see separate report).

313-09351-350-13

MODEL STUDY OF SPILLWAY DEFLECTORS FOR MCNARY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla
(*d*) Experimental; for design.
(*e*) The existing project, located about 2.5 miles upstream from Umatilla, Oregon, includes a 22-bay spillway, a 14-unit powerhouse, an 86-ft by 675-ft navigation lock with maximum single lift of 92 ft, and facilities to pass migratory fish upstream over the dam. Flow under or between upper and lower halves of the vertical-lift spillway gates carries entrained air deep into the stilling basin. This results in excessive amounts of dissolved gases (chiefly nitrogen) that are harmful to fish downstream from the project. The purpose of the tests was to develop a means of spilling flood waters without increasing nitrogen supersaturation. A 1:40-scale model reproduced a three-bay section of the forebay, spillway, stilling basin downstream from bays 1 to 19, and exit channel.
(*f*) Completed; final report in preparation.
(*g*) Air penetration, flow stability, and current directions in the stilling basin, and pressures were determined with and without deflectors. Flow was passed underneath or between upper and lower sections of the gates. Spillway discharges of 13,500 cfs and less per 50-ft bay were of primary concern. Without deflectors, flow for either method of gate operation plunged to the floor of the stilling basin; highly aerated water was distributed uniformly throughout the basin. With 12.5-ft-long horizontal deflectors at elevation 256 and discharge beneath the gates, stable "skimming flow" (with air bubbles confined to the top layer of water) occurred for an 8-ft range in tailwater elevations (257 to 265). Deflectors 20 ft long at elevation 256 were required when flow was passed between gate sections. Additional tests, with deflectors on the spillway chute, will be made in a general spillway model.

313-09352-350-13

MODEL STUDY OF OUTLET FOR MOOSE CREEK DAM, CHENA RIVER LAKES PROJECT, ALASKA

(*b*) U.S. Army Engr. Dist., Alaska.
(*d*) Experimental; for design.
(*e*) Moose Creek Dam, to be located on the Chena River about 17 miles east of Fairbanks, Alaska, will have an average height of about 30 ft and will have an overall length of 7.1 miles. The earthfill dam will divert Chena River flood waters into the Tanana River and provide non-damaging flows in the existing Chena River channel. A proposed outlet channel with riprapped bottom 80 ft wide and riprapped side slopes of 1V on 2H will divert the river from its natural channel upstream of the dam, through the outlet structure, and back to the river downstream from the dam. The outlet works was sized to pass river flows up to 9,000 cfs, small recreation boats, and fish underneath four 25- by 18-ft vertical-lift gates. Two fishways and a fish ladder are proposed for use when velocities through open gate bays exceed 2.5 fps and when flows are being regulated. The purposes of the model study are to check hydraulic performance of the proposed design and to develop revisions if required.
(*f*) Tests completed; final report in preparation.
(*g*) A shallow stilling basin with baffles and a sloping end sill were developed in single-bay, 1:20-scale model. The four-bay outlet structure with fishways and a fish ladder entrance was studied in a 1:40-scale model. The outlet and fishways were satisfactory. The outlet piers were shortened at the downstream end. The upstream approach channel to the outlet was lengthened to produce adequate hydraulic drop between the natural river and the outlet with ungated flows.

313-10658-350-13

GENERAL MODEL STUDY OF SPILLWAY OF LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Lower Monumental Dam is located on the Snake River at mile 41.6 about 32 miles from Ice Harbor Dam. Principal features include a six-unit powerhouse, a 103-foot single lift navigation lock, an eight-bay spillway, and two fish ladders. The spillway was studied in a 1:50-scale general model of the project to determine the effects of flow deflectors on flow conditions at adjacent fishway entrances and to develop an operation schedule for optimum conditions for fish passage.
(*f*) Tests completed; final report in preparation.
(*g*) Satisfactory flow conditions for fish passage and reduction of nitrogen supersaturation were obtained with flow deflectors in five, six, and eight bays of the spillway. An optimum spillway operation schedule was developed.

313-10659-350-13

GENERAL MODEL STUDY OF SPILLWAY OF MCNARY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-09351 for description of project. The spillway was studied in a 1:50-scale general model of the project to determine the effects of flow deflectors on flow conditions at adjacent fishway entrances and to develop an operation schedule for optimum conditions for fish passage.
(*f*) Tests completed; final report in preparation.
(*g*) Satisfactory flow conditions for fish passage and reduction of nitrogen supersaturation were obtained with flow deflectors in all but the end bays of the spillway. An optimum spillway operation schedule was developed.

313-10660-350-13

GENERAL MODEL STUDY OF SPILLWAY OF LITTLE GOOSE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) The spillway was studied in a 1:50-scale general model of the project to determine the effects of flow deflectors on flow conditions at adjacent fishway entrances and to develop an operation schedule for optimum conditions for fish passage.
(*f*) Tests completed; final report in preparation.
(*g*) Satisfactory flow conditions for fish passage and reduction of nitrogen supersaturation were obtained with flow deflectors in all but the end bays of the spillway. Poor fish passage conditions occurred when flow was spilled uniformly from all bays. An optimum spillway operation schedule of nonuniform spills was developed.

313-10661-350-13

GENERAL MODEL STUDY OF SPILLWAY OF ICE HARBOR DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla
(*d*) Experimental; for design.
(*e*) See 313-08445 for description of project. The spillway was studied in a 1:50-scale general model of the project to determine the effects of flow deflectors on flow conditions at adjacent fishway entrances and to develop an operation schedule for optimum conditions for fish passage.
(*f*) Tests completed; final report in preparation.
(*g*) Satisfactory flow conditions for fish passage and reduction of nitrogen supersaturation were obtained with flow deflectors in six, eight, or ten bays of the spillway. An optimum spillway operation schedule of nonuniform spills was developed.

313-10662-350-13

MODEL STUDY OF SPILLWAY DEFLECTORS FOR JOHN DAY DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) See 313-07114 for description of project. Deflectors on the spillway just below tailwater were developed to reduce deep air entrainment in the outflow and nitrogen supersaturation downstream from the spillway. A three-bay section of upstream approach, spillway, and exit channel were reproduced in a 41.14-scale model.
(*f*) Test completed; final report in preparation.
(*g*) Three deflector widths and four elevations were studied with two configurations of downstream topography, and the optimum width and elevation were selected for discharges of 3,000 to 19,300 cfs per bay. Effects of the deflector on flow conditions downstream from the dam, especially on adult fish passage, will be studied in a 1:50-scale general spillway model.

313-10663-850-13

TEST OF FISH SCREENS

(*b*) U.S. Army Engr. Div., North Pacific, Hydro-Electric Design Branch.
(*d*) Experimental; for design.
(*e*) Rotating fish screens are utilized in intakes of powerhouses on the Columbia and Snake Rivers to divert fingerling fish into an intake gate well where they are channeled around the turbines to the tailrace. Little hydraulic data were available for the steel mesh screen in use, and none was available for new plastic meshes being proposed for use. Hydraulic characteristics of flow through four types of mesh with various arrangements of perforated metal plate behind them were observed in a 14.6- by 16-inch water tunnel.
(*f*) Completed.
(*g*) With steel mesh and three plastic mesh screens and various arrangements of perforated metal plates behind them the head drop across the screens and the pull-away force of a simulated fingerling were determined for four approach velocities. The pull-away forces were for comparative use only.
(*h*) **Fish Screen Tests, Lower Granite Lock and Dam,** *Memo. Rept. No. 1*, Div. Hydr. Lab., Feb. 23, 1976.

313-10664-330-13

MODEL STUDY OF NAVIGATION CHANNEL IMPROVEMENTS, BONNEVILLE DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) See 313-07107 for description of the project and the model. The study was made to determine the effect of a new navigation lock location, enlargement of certain narrow reaches of channel, and a new moorage location on the ability of tows and barges to navigate at Bonneville Dam.
(*f*) Completed.
(*g*) Two new navigation lock sites on the Oregon shore near the existing lock have been found satisfactory for navigation. Excavation of a portion of Bradford Island in the forebay enlarges the entrance to the forebay and greatly improves tow maneuverability. A new moorage in the forebay coupled with excavation of a portion of Bradford Island greatly aids navigation with the existing lock. A proposed spur dike extending upstream from the excavated section of the island did not improve fish passage conditions.
(*h*) **Bonneville New Lock,** *Memo. Rept. No. 12*, June 21, 1976, *No. 13*, Apr. 6, 1977, and *No. 14, March 17, 1978, Div. Hydr. Lab.*

313-10666-350-13

MODEL STUDY OF SPILLWAY FOR LIBBY REREGULATING DAM, KOOTENAI RIVER, MONTANA

(*b*) U.S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) The dam will be a rockfill embankment across the river with a combined powerhouse-spillway structure on the left bank. Approach and tailrace channels will be excavated. Power units with 20 to 50 feet of head will be bulb turbines. Preliminary study of the spillway shape and pier was made in a one-bay, 1:50-scale model. Detailed study of the final spillway, power flow passage, and diversion sluice made in a three-bay, 1:35.33-scale model.
(*g*) Characteristics of two spillway shapes and a variety of piers were determined in the 1:50-scale model. Approach and tailrace configuration and flow conditions, diversion sluice rating, spillway rating and pressures, and power flow characteristics and pressures of proposed design determined in 1:35.33-scale model.

313-10667-210-13

CALIBRATION OF PIT ORIFICES AND SERVICE LOOP FOR DOMESTIC WATER SYSTEMS IN ALASKA

(*b*) U.S. Army Engr. Dist., Alaska.
(*d*) Experimental, for design.
(*e*) Pairs of pit orifices 3/4, 1, and 1-1/4 inch in diameter inserted in a 6-inch water main and connected to 25-foot-long service loops of the same size as the pit orifice were tested to determine the head loss in the main due to the orifice, the head drop through the loop, and the water velocity in the loop with various velocities in the main. The data were to be used in determining head loss and heat exchange.
(*f*) Completed.
(*g*) Head loss in the 6-inch main, head drop through the 25-foot loop, and velocities in the loop were determined for three pit orifice and loop sizes with 2- and 4-fps velocities in the main.
(*h*) **Pit Orifice and Service Loop Ratings,** *Memo. Rept. No. 1*, Div. Hydr. Lab., July 15, 1977.

313-11434-350-13

MODEL STUDY OF OUTLET FOR APPLEGATE DAM, APPLEGATE RIVER, OREGON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) Applegate Dam will be a rockfill embankment approximately 245 feet high with a regulating outlet tunnel beneath the embankment and a two-bay spillway in the right abutment. The outlet with oval tunnel, two-stage hydraulic-jump stilling basins, fish barrier, and fish collection facility to be examined and improved in a 1:25-scale model.
(*g*) Deflectors were added to splitter wall from valves to damp rooster tail formation at upstream end of tunnel. Walls at fish barrier between stilling basin raised to contain flow. Other features of design were satisfactory.

313-11435-350-13

MODEL STUDY OF DIVERSION CHANNEL FOR MOOSE CREEK DAM, CHENA RIVER, ALASKA

(*b*) U.S. Army Engr. Dist., Alaska.
(*d*) Experimental; for design.
(*e*) See 313-09352 for description of project. The 2000-foot wide, 9000-foot long channel to divert flood flow to the Tanana River has twin highway bridges and a railroad bridge crossing it and a control sill at the downstream end. The channel was modeled at a scale of 1:100 horizontal to 1:25 vertical for study of flow in the channel and improvement of flow through the bridges. Scour and rock protection requirements at the bridge piers were studied in a 1:15-scale movable bed model. The control sill was developed in a 1:12-scale movable bed flume model.
(*f*) Tests completed; final report in preparation.
(*g*) Improved design of training dikes at the bridges were developed. Fifty percent blockage of bridge openings did not cause overtopping of the dam with the maximum probable flood, which permitted bridge piers to be designed to withstand the project design flood without endangering the dam. Bases of bridge piers near the abutments required rock protection; piers away from the abutments were not endangered by local scour except when retaining large amounts of debris. A control sill requiring no rock protection except at the abutments was developed.

313-11436-850-13

GAS EQUILIBRATION OF WATER SUPPLY OF FISH TRANSPORT BARGE

(*b*) U.S. Army Engr. Div., North Pacific.
(*d*) Experimental; for design.
(*e*) Migrant fingerling fish from the Snake and Columbia Rivers are being transported by barge around the dams on the rivers to lower the loss of fish. The barges circulate fresh river water through the holding chambers. The water can be supersaturated with dissolved gas and harmful to the fish. A section of 12-inch supply manifold was assembled in a test stand to determine the equilibration capability of the system and to develop an alternate system if needed. Equilibration of flow through packed columns (vertical pipes filled with plastic rings) was tested.
(*g*) Splash plates 1 foot from manifold outlets were effective in reducing nitrogen saturation of 130 and 140 percent to 109 and 113 percent. A 10-inch-diameter packed column with 4 feet of plastic rings reduced 130 percent saturation to 102 percent.
(*h*) **Fish Transportation Barge Water Supply Nitrogen Supersaturation Reduction,** *Memo. Rept. No. 1*, Div. Hydr. Lab., May 16, 1978.

313-11437-350-13

MODEL STUDY OF SPILLWAY FOR APPLEGATE DAM, APPLEGATE RIVER, OREGON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) Applegate Dam will be a rockfill embankment approximately 245 feet high with a regulating outlet tunnel beneath the embankment and a two-bay spillway in the right abutment. A portion of reservoir, approach channel, spillway with chute and double flip buckets, and 2200 feet of downstream river channel are modeled at a scale of 1:30 for study of spillway flow and effectiveness of the flip buckets as energy dissipators.
(*g*) Approach channel excavation was reduced. Flow in the approach and at the bridge to the outlet control tower was satisfactory. Flow and waves at the downstream toe of the embankment were satisfactory with all flood discharges.

313-11438-340-13

MODEL STUDY OF ICE AND TRASH CHUTE FOR BONNEVILLE SECOND POWERHOUSE, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) See 313-07107 for description of project. The ice and trash chute was modeled at a scale of 1:20 for study of withdrawal of flow for emergency auxiliary water supply for fish facilities and for passage of trash.
(*g*) Flow withdrawn through a proposed side wall intake for fish facility water supply would be satisfactory. Trash passage will be studied.

DEPARTMENT OF THE ARMY, WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS, P.O. Box 631, Vicksburg, Miss. 39181. F. R. Brown, Engineer, Technical Director.

These project summaries are abridged from more detailed descriptions appearing in the FY 1979 Civil Works Annual Research and Development Summary, Vols. 1 and 2, Office of the Chief of Engineers, Washington, D.C. 20314.

314-06849-400-13

MODEL STUDY OF CHESAPEAKE BAY

(*b*) Baltimore District, North Atlantic Division.
(*c*) David Bastian, Estuaries Branch.
(*e*) The Estuaries Branch has been given the responsibility for assisting the Baltimore District in the design, construction, verification, and testing of a hydraulic model of the Chesapeake Bay. The model will be utilized to assist in formulating and recommending solutions to priority problems relative to the water resources of the Chesapeake Bay and tributaries. A fixed-bed, comprehensive model of the Chesapeake Bay and tributaries with linear scale ratios of 1:100 vertically, and 1:1000 horizontally, has been constructed. The model has the capability of reproducing tides, current velocities, salinities, hurricane surges, and freshwater inflows.
(*g*) Model dedicated May 1976. Adjustment and verification completed. Project testing initiated.

314-09667-330-13

LOCK AND DAM 26, MISSISSIPPI RIVER

(*b*) Lower Mississippi Valley Division.
(*c*) L. J. Shows.
(*e*) Determine whether the existing structure should be modernized by adding an additional lock or whether a new structure should be provided. A model study was conducted which encompassed the reach between river miles 199.0 and 205.7 on the Mississippi River. The model was built to an undistorted scale of 1:120. The model is of the fixed-bed type reproducing locks and dam structures and adjacent overbank area between the levees.
(*g*) A draft of the final report has been prepared and a copy was forwarded to the District for review and comments. Publication of the final report will be undertaken upon receipt of the District's comments and authorization of funds for publication. Additional testing may be required after Congressional authorization of the project is obtained.

314-09670-300-13

MISSISSIPPI RIVER PASSES–40-FT CHANNEL

(*b*) Lower Mississippi Valley Division.
(*c*) H. A. Benson.
(*e*) Investigate plans for the reduction of shoaling in the existing 40-ft channel. A fixed-bed model reproduces the Mississippi River downstream from 14 miles above Head of Passes, including South and Southwest Passes and portions of Pass a Loutre and Cubits Gap, and a portion of the Gulf of Mexico. Model scales are 1:100 vertically and 1:500 horizontally.
(*g*) Hydraulic adjustment of the model and shoaling verification of the Head of Passes area have been completed. Base shoaling tests and tests of dredging methods have been

completed. Tests of plans to reduce shoaling at Head of Passes with the existing channel depth have also been completed. Interim reports of all studies of the Head of Passes have been furnished the district. Tests to assure proper reproduction of hydraulic phenomena and salinity intrusion in Southwest Pass have been completed. Tests to obtain a shoaling verification of Southwest Pass below Head of Passes have been completed. Additional plan shoaling and hydraulic tests in Southwest Pass are currently underway.

314-09671-330-13

MODEL STUDY OF ALEXANDRIA REACH, RED RIVER

(*b*) Lower Mississippi Valley Division.
(*c*) L. J. Shows.
(*e*) Determine the modification required to bridges in the reach and the type and location of regulating structures required to develop a satisfactory navigation channel through the reach. An undistorted fixed-bed model was constructed to a scale of 1:100, model to prototype. The model encompasses about four miles of the river channel including the five bridges through the reach as well as adjacent overbank areas between levees.
(*g*) All originally scheduled tests have been completed and the results, in preliminary form, furnished the District. Authorized testing has been completed and preparation of a draft of the final report has been undertaken.

314-09672-330-13

MODEL STUDY OF EMERGENCY BULKHEAD CLOSURE, MISSISSIPPI RIVER GULF OUTLET LOCK

(*b*) Lower Mississippi Valley Division.
(*c*) G. A. Pickering.
(*e*) Study the emergency closure for the 150- by 1200-ft lock. A 1:50-scale model will be used to reproduce the entire chamber and an appropriate length of canal at each end. The bulkheads will be reproduced accurately to scale, size, shape, and weight. One pair of miter gates may be accurately reproduced to scale so that the possibility of their use for emergency closure can be tested. (This was not included in model estimate of the proposal.) Model tests will be concerned with determining loads acting on the closure during emergency placement. The problem will be unusual due to the width of the lock being 40 ft greater than closures previously studied.

314-09673-330-13

MODEL STUDY OF FILLING AND EMPTYING SYSTEM FOR MISSISSIPPI RIVER-GULF OUTLET LOCK

(*b*) Lower Mississippi Valley Division.
(*c*) G. A. Pickering.
(*e*) Objective is to develop a filling and emptying system for use by both ship and barge traffic. The designs for intakes, outlets, port manifold, and valves must be adequate under normal and reverse head conditions indigenous to the proposed site. The model reproduces the entire filling and emptying system, the lock chamber, and portions of the approaches at a scale of 1:25. Usual instrumentation was provided. The efficiency of the manifolds operating under reverse head conditions could not be computed but were checked. In addition, the magnitude of surges and velocities which can be expected were determined. The tests included a range of probable conditions and valve operating schedules.
(*f*) Completed.
(*g*) All testing was suspended after sufficient data on the side port system Type 15 (recommended) were furnished during a conference at WES on 13 February 1975. All tests of the side port system are complete unless additional tests are requested.
(*h*) **Filling and Emptying System, New Ship Lock, Mississippi River-Gulf Outlet, Louisiana,** *TR H-78-16*, Sept. 1978.

314-09674-350-13

MODEL STUDY OF MERAMEC PARK RESERVOIR OUTLET WORKS

(*b*) Lower Mississippi Valley Division.
(*c*) N. R. Oswalt.
(*e*) To develop an adequate stilling basin design and determine the size and extent of stone protection required for the exit channel.
The scale of the model was changed to conform with the change in conduit size (22-ft wide reduced to 14-ft wide) specified by the District. Tests were conducted in a 1:25.5-scale model in which a 160-ft-wide and 260-ft-long approach area, the intake structure, transition, conduit, stilling basin, and 650 ft of exit channel were reproduced.
(*g*) A 36-ft-long horizontal apron downstream from the exit portal reduced the influence of the waves in the conduit by permitting flow to spread as it emerged from the conduit. Eddies that formed in the stilling basin during low flows were eliminated by providing a 1 on 16 sidewall flare. A satisfactory stilling basin was developed and the size and extent of exit channel riprap protection was determined. All tests have been completed.
(*h*) **Outlet Structure for Meramec Lake, Meramec River, Missouri,** *Technical Report H-78-15*, Oct. 1978.

314-09677-330-13

MODEL STUDY OF SHOALING IN SAWYER BEND AND ENTRANCE TO CHAIN OF ROCKS CANAL (MISSISSIPPI RIVER)

(*b*) Lower Mississippi Valley Division.
(*c*) J. E. Foster.
(*e*) Investigate various plans to eliminate shoaling in Sawyer Bend and improve shoaling conditions in the lower entrance to Chain of Rocks Canal. A movable-bed model with scale ratios of 1:250 horizontally and 1:100 vertically reproducing the Mississippi River from about river mile 169.0 to 190.8 was used for the study.
(*g*) Plans have been developed to eliminate shoaling in Sawyer Bend and reduce shoaling in the entrance to Chain of Rocks Canal. Tests indicated Phase I of the construction program would be effective in improving shoaling in Sawyer Bend.
(*h*) **Shoaling Conditions in Sawyer Bend and Lower Entrance to Chain of Rocks Canal, Mississippi River,** *Technical Report H-78-7*, June 1978.

314-09680-350-00

OLD RIVER DIVERSION MODEL STUDY, FIXED BED

(*b*) Lower Mississippi Valley Division.
(*c*) T. J. Pokrefke.
(*e*) Objective is to provide hydraulic data required to develop plans for repairs to the existing low sill structure; to determine the effects of various methods of gate operation at the low sill structure on current velocities, current directions, and stages; to develop the hydraulic design of rock weirs or other structures that might be required to insure the safety of the existing low sill structure; to provide hydraulic data that might be required for site selection and design of a new low sill structure; to determine the effects of plans developed in the movable-bed model on hydraulic conditions at the existing low sill structure and for a possible new low sill structure; and to provide hydraulic data useful for the design of the proposed four-gated auxiliary structure. Initially the study was conducted on a 1:120-scale, fixed-bed model extending from river mile 313.0 to 318.5. Subsequently, the model was extended downstream to mile 306.0 and revised to the December 1974 conditions.
(*g*) Tests requested by the District on the existing structures and channel with the August 1973 conditions have been completed. Tests of proposed rock weirs and of a series of piling in the ouflow channel to control the distribution of flow through the existing structures and to insure the continued security of the low sill structure have been

completed. Inflow channel improvement tests have been completed. Tests have been completed on a barge barrier to reduce the possibility of loose barges entering the inflow channel. Tests to provide data for the proposed Operation and Maintenance Manual are completed. Tests on the overbank structure modifications have been completed. Testing of the four-gated auxiliary structure have been undertaken.

314-09687-470-13

NEWBURYPORT HARBOR MODEL STUDY

(*b*) New England Division.
(*c*) N. J. Brogdon, Jr.
(*e*) Investigate proposed plans and/or modifications to existing projects in an effort to determine their effects on channel shoaling in the harbor entrance, small boat navigation, erosion of Plum Island Point, existing salinity conditions, and water quality. A combination fixed-bed and movable-bed model has been constructed, which includes a portion of the Atlantic Ocean, Newburyport Harbor, and the Merrimack River to head of tide. Linear scales are 1:100 vertically and 1:300 horizontally. The model is equipped to reproduce tides, tidal currents, wave action, density currents, and freshwater inflows.
(*g*) The current testing program has been completed.

314-09717-300-13

MODEL STUDY OF SUCK BEND, CHATTAHOOCHEE RIVER

(*c*) J. E. Glover.
(*e*) Objective is to develop a satisfactory plan for the elimination or reduction of shoaling in the area. The study was conducted on a 1:72 scale movable-bed model extending from river mile 72.9 to about mile 74.4.
(*g*) A plan which would reduce shoaling and provide a satisfactory navigation channel through the reach has been developed.
(*h*) Final Report published June 1978.

314-09719-330-13

MODEL STUDY OF ALICEVILLE LOCK AND DAM, TENNESSEE-TOMBIGBEE WATERWAY

(*c*) L. J. Shows.
(*e*) Study navigation conditions in the lock approach and current conditions in the diversion canal during construction of the lock and dam. The model is of the fixed-bed type constructed to an undistorted scale of 1:100, reproducing about three miles of the Tombigbee River Channel near Pickensville, Alabama. Lock and Dam diversion canal and adjacent overband areas.
(*g*) Satisfactory navigation conditions can be developed in both the upstream and downstream lock approaches at the proposed site.
(*h*) Final Report published April 1978.

314-09722-330-13

MODEL STUDY OF ABERDEEN LOCK AND DAM

(*b*) Mobile District.
(*c*) L. J. Shows.
(*e*) Develop plans which will provide good navigation conditions in the lock approaches and minimize the adverse effects of the large left overbank flow on tows moving through the navigation channel during high stages. The model is of the fixed-bed type, constructed to an undistorted scale ratio of 1:120, and reproduces a short reach of the Tombigbee River upstream and downstream of the dam, the approach channel to the lock, the lock and dam structure, and the adjacent overbank areas.
(*g*) Satisfactory navigation conditions can be developed in both the upstream and downstream lock approach at the proposed location. The effects of the cofferdam on flood flow stages would be minor and the effects on current velocities would be local.
(*h*) Final Report published June 1978.

314-10742-320-00

EFFECTS OF WATER FLOW ON RIPRAP IN FLOOD CHANNELS

(*c*) S. T. Maynard, N. R. Oswalt.
(*e*) To develop adequate criteria for design of stable riprap linings for flood channels to reduce costly maintenance and repair along flood control channels. Riprap protection along flood control channels continues to fail and require high annual maintenance and repair costs. Facilities required for systematic tests of a variety of stone sizes greater than 1-2 inches are not available. A large discharge capacity channel research facility is scheduled for construction during FY 79-81 which will permit systematic tests and collection of appropriate data needed to develop adequate criteria for design of stable riprap protection in straight and curved reaches of channels. During the interim, research is being conducted in existing facilities to address the effects of side slope, gradation, and gradually varied flow on riprap stability in straight flood channels. Existing facilities will also be used to determine the effects of curved reaches on riprap stability.
(*g*) Guidance based on the Froude number concept for sizing riprap on various side slopes in straight channels was published in Miscellaneous Paper H-78-7. Tests to determine the effects of gradation on riprap stability in straight channels were initiated. Guidance developed to date was presented to various offices of the Corps during a short course, "Hydraulic Design of Open Channels," during FY 78.

314-10743-330-00

RELATIONSHIP OF BENDS AND CHANNEL WIDTHS FOR PUSH TOWING

(*c*) L. J. Shows.
(*e*) To develop criteria which would establish a basis for reasonable design for navigation channel width in bends on inland waterways. With a known tow size and the maximum deflection angle (angle between the tow and a tangent to the curve at the stern of the tow) assumed by the tow in navigating a particular bend, the required channel width can be easily computed. However, the deflection angle is dependent on many factors, some of the most critical of these are: (1) radius of curvature, (2) degrees of curvature traveled by tow, (3) tow draft, width, and length, (4) speed of tow in relation to currents, (5) direction and velocities of currents, (6) direction of travel of tow (upstream or downstream), (7) tow flanking or drifting around the bend, (8) alignment and position of tow entering bend, (9) relationship of navigable channel limits to the bank lines (particularly the concave bank). An undistorted semi-fixed bed hydraulic model reproducing typical river bends to a scale ratio of 1:120 and remote control model towboats will be used in model tests to establish the relationship between bend radii and tow deflection angles. The model will be operated with a constant flow condition in the bendways with different radii. The model towboat representing the different tow sizes will be operated through the model and the channel section wil be altered to provide a minimum channel which would be considered safe for a particular size tow.
(*g*) Results of the research study showing maximum deflection angles required for tow sizes 35 by 685 ft, 70 by 685 ft and 105 by 600 ft in bendways with radii ranging from 1500-3000 ft, were published in Engineer Technical Letter No. 1110-2-225 dated July 1977. Testing of the 4000 ft to 10,000 ft radii with tow sizes 35 by 685 ft, 70 by 685 ft, 105 by 600 ft and 105 by 1200 ft was accomplished.

314-10744-330-00

IMPROVED CRITERIA FOR LOCK DESIGN

(*c*) G. A. Pickering, J. H. Ables, Jr.
(*e*) To disseminate the existing state-of-the-art and to provide improved criteria for design of the several types of lock filling and emptying systems. In the past, designs have been accomplished largely by empirical methods based on

results of hydraulic model studies of specific structures. Guidance for design of each of the several types of lock filling and emptying systems is needed. Comprehensive model tests are being conducted on different types of filling and emptying systems to obtain data over a wide range of conditions. Analysis of tests and other available data will result in improved generalized design information.

(*g*) Research has been conducted in various specific models to obtain data for developing generalized and improved criteria for lock filling and emptying systems. Results of some of these tests and recommended design procedures for a sidewall port filling and emptying system were published in Miscellaneous Paper H-75-7, "Lock Design, Sidewall Port Filling and Emptying System," in July 1975. EM 1110-2-1610, "Hydraulic Design of Lock Culvert Valves," was published during August 1975. This manual will result in improved operating conditions for lock valves. Generalized data were obtained with various lifts from a specific model study of a 110-ft wide by 600-ft long lock with a longitudinal floor culvert system. These data were analyzed.

314-10746-350-00

GENERAL SPILLWAY TESTS

(*c*) J. L. Grace, Jr., S. T. Maynard.

(*e*) To obtain additional basic knowledge and improved criteria for design of spillway crest shapes and stilling basin sidewalls. This information will provide an improved universal design procedure for both low and high overflow spillways. Data required for generalized description of the discharge coefficients, pressures, water surface profiles and pier contraction coefficients of low and high spillways with simple elliptical upstream quadrants that are recommended for CE projects are not sufficient for preparing required hydraulic design charts. Systematic model tests will be conducted to supplement the design procedure recommended for low spillways in MP H-73-5, "Spillway Crest Design." Discharge coefficients, pressures, water surface profiles, and pier effects will be determined for various approach depths, upstream slopes, and heads on the spillways with and without crest piers.

(*g*) Pressures on spillways with four different shapes of the upstream quadrant were published in Research Report H-70-1. Currently recommended guidance for design of low and high spillways with simple elliptical upstream quadrants (without surface discontinuities) was published in Miscellaneous Paper H-73-5, "Spillway Crest Design." The lack of pertinent data for preparation of appropriate guidance, Hydraulic Design Criteria Charts and updating of EM 1110-2-1603 "Hydraulic Design of Spillways" was recognized and a program of systematic tests to obtain the urgently needed information was formulated. The experimental facilities have been constructed to permit generalized tests and improved techniques for recording, analyzing and displaying results in a timely and effective manner. Tests of crests with $p/H_d = 0.5$ have been completed and tests of crests with $p/H_d = 0.25$ are in progress.

314-10747-330-00

LOCK CULVERT VALVE VENTILATION

(*c*) G. A. Pickering, D. B. Murray.

(*e*) To obtain satisfactory air venting at lock culvert valves by means of an expansion immediately downstream of the valve with resulting negative pressures sufficient for venting and reducing cavitation potential in lieu of expensive lowering of the culverts to reduce the potential for cavitation. Many tests have been conducted in efforts to raise the minimum pressure gradient immediately below a valve to eliminate cavitation tendencies, but no tests have been conducted toward lowering this gradient. The result of the proposed expansion of the roof may result in negative pressures on the roof of the culvert adequate to assure satisfactory venting at a cost of only a few tenths of a minute in filling time. A 1:25-scale model is being used for the study. Various degrees of expansion will be tested to determine the effect on the pressure gradient immediately downstream from the valves. This information will offer an inexpensive method of reducing and/or eliminating cavitation at lock culvert valves as well as improving the quality of water released.

(*g*) Test facility was constructed and testing was initiated with a square culvert (no expansion) to obtain base data for use in determining the effect of various expansions.

314-10749-410-00

EDUCTOR SYSTEMS FOR SANDTRAP BYPASSING

(*c*) E. C. McNair, Jr., W. B. Fenwick.

(*e*) To develop effective systems for bypassing sand at tidal inlets and other obstructions to littoral transport. Bypassing of sand and channel maintenance of tidal inlets are generally difficult and expensive operations. More efficient methods are required to properly maintain these inlets located along the shores of the Atlantic Ocean, gulf coast, Pacific Ocean, and Great Lakes. An evaluation of existing and proposed bypassing arrangements has identified the jet pump eductor as having great potential in sand bypassing applications and can be assembled into a reliable, low-cost, easy-to-operate system. The jet pump eductor, though used primarily as a suction booster on dredge pumps, can be arranged in a pumping system in such a manner that the jet pump becomes the primary solids-handling component in the system. However, little information was available from the literature or from the dredging industry on the criteria for system design or on deployment and operational techniques. Therefore, a research program employing laboratory and field studies was designed and implemented. Laboratory investigations are providing information on basic system behavior which can be translated into design concepts. Preliminary deployment and operational procedures have been evaluated in the laboratory setting. Field studies are underway to finalize the initial concepts and to test the ruggedness and performance of the systems as a whole. The field studies are being performed at a series of sites beginning with mild wave and tidal conditions and progressing through severe wind and tidal conditions. The major coasts of the United States are included as test sites.

(*g*) Extensive laboratory and field experiments have been performed. Tests at sites on the Florida gulf coast, the Atlantic coast at Rudee Inlet, Virginia, and the Pacific coast at Santa Cruz Harbor, California, have shown the jet pump system to be an effective approach to sand bypassing at the smaller harbors and tidal inlets. Design information has been acquired from laboratory tests and operational methodology has been developed from the field experiments.

314-10757-870-00

ROLE OF LAGOONS IN SMALL-SCALE WASTE TREATMENT SYSTEMS

(*c*) A. J. Green, N. R. Franceingues.

(*e*) Recognizing the potential of lagoons as a low cost, low maintenance, technologically simple means of wastewater treatment, it is the objective of this work unit to disseminate current technical information specifically useful to the Corp's problems in the field and to develop and disseminate improved design and operational methods so that the treatment effectiveness of lagoons can keep pace with increasingly stringent Federal and State requirements. Research will be conducted to investigate those areas of lagoon behavior that have specific application to Corps problems. These research areas were identified in the FY 77 survey report "The Role of Sewage Lagoons at Corps of Engineers Recreation Areas" and include: controlled discharge from seasonally loaded lagoons in mild winter areas: in pond chemical coagulation for algae sedimentation; inlet and outlet devices, structures and techniques; liners; sludge accumulation in recreation area lagoons and use of flora and fauna for upgrading lagoon performance. A constant review of the literature on lagoon design, performance, and research will be maintained, and pertinent information will be passed on to the field in conjunction

with research results or in separate circulars. This review will include continuous coordination of activity with the U.S. EPA and other Federal and nonfederal agencies having an interest in lagoons. In addition to one or more annual Engineering Circulars or Technical Letters to be published by OCE for the dissemination of results from activities described above, all significant findings will be incorporated in a final technical report and/or lagoon design and operation manual or chapter in existing manuals. Particular attention will be paid during all aspects of this work unit to determine cost information and money saving innovations consistent with meeting Federal and State discharge and/or water quality standards.

314-10759-330-00

CHANNEL DIMENSIONS AND ALIGNMENT FOR SAFE AND EFFICIENT NAVIGATION

(*c*) G. A. Pickering, H. O. Turner.
(*e*) To determine the minimum dimensions of navigation channels compatible with the assurance of safe operating conditions. A study of existing navigation channels indicates a wide range of dimensions, many of which are not attributable to differing sizes of using vessels or local operating conditions. Many channels appear to be excessively large, thus causing excessively high construction and maintenance costs, while other channels are so small that they incur a disproportionate number of accidents or require such low speeds and careful operation as to inhibit ship movements. Either situation is undesirable and the increasing use of very large ships will cause these basic design differences to become even more serious. It is imperative that rational maintenance procedures be established in order that channel dimensions and maintenance dredging can be minimized while still maintaining safe and efficient navigation conditions. There are several items that influence design and maintenance of navigation channels. Some of these are ship dimensions, ship power to weight ratio, rudder and propeller assemblies, type of traffic, ship speed, pilot ability and weather conditions. Curves will be developed to define channel dimensions in terms of these pertinent variables. The data will be published in a comprehensive research report.
The research program will be carried out primarily as a physical model study utilizing free running model ships. The tests required to develop the channel design curves will be conducted with several different types and sizes of ships (tanker, mariner and container) constructed to a scale of 1:100. A series of tests will be conducted with two larger model ships (1:25 and 1:50-scale) to determine model scale effects and permit adjustment of the results of tests with 1:100-scale ships to assure that prototype ship maneuverability is reproduced. Five measurements will be taken during each ship passage; one of the measurements will be qualitative (good or bad) and the other four will be quantitative. The qualitative measurement will be considered bad if the vessel strikes the model banks or bottom during a test run and good if it does not. The quantitative measurements will be the ship speed, rudder angle, ship heading and lateral deviation of the ship's center of gravity from the intended course. Each run will provide a point of either "safe" or "unsafe" navigation which will be used to establish improved guidance for design and maintenance of deep draft nagivation channel dimensions and alignment.

314-10760-350-00

PIPING AND RAINFALL EROSION IN DISPERSIVE CLAY EMBANKMENTS

(*b*) Lower Mississippi Valley Division.
(*c*) E. B. Perry.
(*e*) To study piping and rainfall erosion in dispersive clay embankments such as Grenada Dam, Mississippi. Pinhole erosion tests will be conducted to study the erodibility of embankment slopes. Pinhole tests, using reservoir water as the eroding fluid, will be conducted on undisturbed foundation material to determine the susceptibility to dispersive clay piping.
(*g*) The laboratory testing program has been completed. The final report was submitted to LMVD in July 1978; approval for publication is pending.

314-11518-440-00

RESERVOIR HYDRODYNAMICS

(*c*) J. L. Mahloch.
(*e*) Objective is to develop, evaluate, improve and verify methods for describing and predicting the hydrodynamics of reservoirs to provide a basis for improved understanding of water quality and ecological variables affecting environmental quality objectives. The problem is to predict the effects of reservoir hydrodynamics on the water quality and ecology. Since the movement of water in reservoirs dictates the movement of water quality constituents, prediction and evaluation of water quality and environmental effects depend on an accurate understanding of reservoir hydrodynamics. Physical and mathematical modeling techniques are the only way to describe reservoir hydrodynamics. Appropriate techniques need to be compared and verified relative to field data and conditions. Literature reviews, laboratory experiments, physical and mathematical models, field experiments and observations, and analytical studies are being used to develop and verify new and improved methods of describing reservoir hydrodynamics so that water quality and ecological characteristics can be better evaluated. Specifically, the following tasks are being addressed under this work unit: (1) Develop and verify techniques for describing reservoir inflow mixing processes. (2) Develop and verify techniques for describing internal reservoir mixing processes. (3) Improve and verify physical hydrodynamic modeling techniques for reservoirs. (4) Improve and verify multi-dimensional hydrodynamic mathematical models. (5) Develop and verify techniques for describing pump-back mixing processes in reservoirs. (6) Develop criteria and techniques for predicting the behavior of fine sediment in reservoirs. (7) Develop criteria and techniques for forecasting the development of reservoir deltas.
(*g*) Techniques for describing the reservoir inflow and internal mixing were identified and efforts to test and evaluate these techniques were initiated. Physical hydrodynamic models were used to simulate and initiate studies of internal density currents. The capability of two existing multi-dimensional mathematical models for simulating and predicting reservoir hydrodynamics was evaluated and found to need improvement and additional development.

314-11519-330-00

NUMERICAL PREDICTION OF NAVIGATION CHANNEL MAINTENANCE

(*c*) W. A. Thomas.
(*e*) Objectives are to develop numerical prediction techniques for assessing the impact of changes in sediment loads, water discharges, flow hydraulics, dredging frequency, channel size, or disposal techniques on the quantity of sediment being dredged and frequency of the dredging operation. When the navigation depth exceeds the equilibrium depth between the sediment load/grain size and flow hydraulics, there might be more economical alternatives for providing the necessary depth than those presently being used. Investigations are hampered by a lack of an analytical technique for understanding the system. The computer code "Mathematical Model of Estuarial Sediment Transport" developed by Ariathurai, MacArthur, and Krone for the Dredged Material Research Program will be enhanced to become a general purpose sediment transport model capable of analyzing noncohesive as well as cohesive sediment problems. The program will be documented and guidelines prepared to aid field office personnel in applying it. It will be made available for field offices to use. A companion program, "A Finite

Element Model for Lower Granite Reservoir," developed for Walla Walla District, CE, by King and Norton and subsequently enhanced via many applications will be linked with the WES version (STUDH) of Ariathurai's horizontal model via an existing data management system (DMS). The hydraulic parameters (velocity vectors and depth) will be calculated and passed to STUDH where sediment transport calculations will be made and resulting bed elevation changes returned to the hydraulic codes via DMS. This weakly linked computational model will be useful in all well-mixed flow fields which have consistent velocity directions from the water surface to the bed. Throughout this research period, the performance of STUDH will be related to and compared with the work of others. Particularly, alternative transport functions for the behavior of cohesive sediments will be sought and promising techniques will be added to STUDH as options. Sediment models HEC6 and the Florida model will be revised and tested for comparison with STUDH.

314-11520-860-00

SIMPLIFIED TECHNIQUES FOR PREDICTING RESERVOIR WATER QUALITY AND EUTROPHICATION POTENTIAL

(*c*) Dr. J. L. Mahloch.

(*e*) Objective is to evaluate existing simplified and empirical techniques for predicting lake water quality and eutrophication potential to determine their applicability to reservoirs and provide a basis for adaptation and improvement for CE reservoir applications. Models proposed for use in managing impoundment water quality range from the relatively simple, empirical models of Vollenweider, Dillon, and Carlson to the more complex, theoretical models such as WQRRS. While the more complex models can probably be applied to a wider range of questions, the simplicity and relatively low data requirements of empirical models are important.

During the planning phases of many projects, including proposed projects or operational changes in an existing project, the time, funding, and data base required to properly implement a complex model may not exist. During the planning phase, it would be desirable to have simple models with low data requirements and computational requirements that could be used to screen various project alternatives and select those alternatives appropriate for more detailed study. For example, if several sites are feasible from engineering studies, simplified eutrophication procedures could be used to investigate water quality and reduce the number of possibilities for further consideration to one or two.

A major problem with most simplified techniques is that they have been developed on generally small and restricted data bases–primarily natural lakes in the northern temperate zone. The generality and transferability of these models have not been investigated or demonstrated. In several instances, the parameters in these models have been subjectively determined such as the placement of the permissible and dangerous lines on Vollenweider loading plots.

A comprehensive survey will be conducted to determine empirical techniques with predictive value considered appropriate and technically feasible for adaptation to reservoirs. Approaches such as those developed for natural lakes by Vollenweider, Dillon, Brezonik, and others will be investigated. Those techniques showing promise will be evaluated in detail and improvements made for application to reservoirs. Considerations when making improvements will include the inherent differences between natural lakes and reservoirs (i.e., residence time, hydrodynamics, inflow/outflow, loading characteristics, etc.). New techniques will be developed to address problems where existing procedures are not available but are needed. Improved and developed techniques will be applied and verified.

314-11521-860-00

TECHNIQUES FOR PREDICTING ANNUAL LOADINGS TO RESERVOIRS

(*c*) Dr. J. L. Mahloch.

(*e*) Objective is to evaluate loading prediction techniques for total sediment, total nitrogen, and total phosphorus, such as Midwest Research Institute, EPA's National Eutrophication survey (Omernik's Report), regression equations, flow weighting, average flow and concentration, and flow interval methods, with respect to ease and generality of application, consistency of results, data requirements, and technical expertise required. Nonpoint source runoff results in loadings of chemical constituents and suspended solids that directly affect reservoir water quality and management operations. Field offices are asked to predict the impact of changes in watershed activites on the water quality of inflows to existing and proposed impoundments. Existing techniques must be evaluated to determine their capability for predicting loadings to impoundments and predicting changes in loadings produced by land-use changes in the watershed. After evaluation, recommendations can be made concerning appropriate predictive techniques, associated data requirements, and methods of data analysis and interpretation. Data currently available at WES from the Caddo River drainage basin and from the Sandusky River basin will be used with all methods to calculate loadings. The calculated annual loadings from each method will be compared. A comparison of the methods will be presented in the form of a matrix with the techniques subjectively ranked on the relevant features presented in the objectives.

(*g*) A survey of CE field offices determined the techniques used for predicting annual loadings to CE reservoirs. An interagency workshop was held with U.S. Forest Service, U.S. EPA, USDA-SEA, and USGS to discuss and recommend other existing techniques that might have potential in prediction of annual loadings to reservoirs. Loading computations for suspended solids, total nitrogen, and total phosphorous were made using techniques such as Midwest Research Institute, EPA's National Eutrophication Survey (Omernik's Report), regression equations, flow weighting, average flow and concentration, and flow interval methods. Two existing sets of data were used in the computations, one from the Caddo River drainage basin and one from the Sandusky River basin.

314-11522-700-00

INTEGRATED HYDROGRAPHIC SURVEY SYSTEMS

(*c*) E. D. Hart.

(*e*) Objective is to develop effective and efficient hydrographic survey methods, systems and equipment. The findings will be used by Corps districts in continually determining bottom profiles and the location of shoals and other hinderances to navigation. Because of the great amount of surveying required, the district must utilize the most efficient, accurate, automated equipment available. The increasing waterways traffic and smaller district survey units demand that surveys be conducted accurately in the least possible time. This requires continuous updating of equipment and methods. Approch is to monitor district needs and problems in hydrographic surveying; continually search for and evaluate existing and new systems and equipment; provide results to districts; oversee development of new systems and equipment as required.

(*g*) A literature search and canvass of manufacturers' equipment and district needs have been made and will continue. A lack of small boat survey equipment was detected and corrected through equipment development and district evaluation. Corps-wide conferences were initiated and are continuing to provide manufacturer-Corps contact. A final report on positioning equipment and capabilities was published and distributed. Other equipment development, based on indicated district needs includes a doppler velocity meter and sweep scanning equipment. Assistance to districts on a continuing basis is provided as requested.

314-11523-330-00

MATH MODELS AND SHIP SIMULATOR STUDIES FOR NAVIGATION CHANNEL DESIGN AND OPERATIONAL GUIDANCE

(*c*) C J Huval.

(*e*) Objective is to develop and use a mathematical model and a ship handling simulator to develop guidance concerning the effects of pilot response on navigation channel design criteria and furnish operational information. Present channel design is inadequate and does not consider dynamic ship-channel interaction or the human piloted ship in setting safe and economical channel dimensions. In the physical model tests, time is scaled with the result that events occur much more rapidly during the model test than in prototype ship movements. The effect of this time scale distortion on pilot response is an open question in the scientific community. The research effort is directed to the implementation of an available mathematical model for calculating ship motion and the development of a research ship simulator. The study will complement and extend the physical model effort conducted under 314-10759-330-00. The mathematical model will be used to calculate ship motion in deep water and various channel configurations being tested with the physical ship models. The detail specifications for a research ship simulator will be formulated and the procurement of the necessary hardware and software will be undertaken. Following delivery of the simulator, studies will be conducted to determine the effects of such factors as time scale distortion, varying navigation aids and pilot response to ship transients on navigation channel design. The emphasis in this work unit will be to bring the man into the ship control loop and to ascertain the effect of the pilot's ability on safe and efficient navigation channels.

(*g*) A preliminary study on the applicability of math models and ship simulators to channel design has been completed as a part of 314-10759-330-00. This study has revealed that studies involving the piloted ship in undistorted time are required to evaluate human aspect of proper navigation channel design.

314-11524-350-00

DESIGN AND CONSTRUCTION OF GRANULAR FILTERS FOR EMBANKMENT DAMS

(*c*) W C. Sherman, Jr.,

(*e*) Objective is to conduct laboratory filter tests on various soil-filter combinations to develop improved filter criteria for intact and cracked core materials used in earth and rockfill dam construction. Evaluate field performance of filters currently employed in embankment dam construction. Laboratory tests will be conducted in four different phases. In the first phase, laboratory filter tests will be conducted on uniform and graded cohesionless materials to check the adequacy of the existing CE criteria. In particular, it will be determined whether the requirement for parallel gradiations is necessary and whether supplementary stability ratios are necessary in the case of widely graded base or filter materials. The second phase will involve tests to establish criteria for filter materials. The second phase will involve tests to establish criteria for filter requirements for nonplastic base materials. In the third phase, tests will be performed to establish criteria for filter requirements for cracked cores of cohesive material. The fourth phase will involve laboratory experimental studies of internal stability of filter materials. The studies will be preceded by a review of past laboratory filter research. Various agencies and CE offices will be contaced regarding design and construction experiences with filters of earth and rockfill dam construction. Field performance data will be evaluated.

314-11525-350-00

FLOW OF WATER THROUGH ROCK MASSES

(*c*) W O. Miller.

(*e*) The objective is to determine accurate and reliable permeability measurement techniques and seepage analysis methods applicable to predicting seepage patterns, gradients, rates, and uplift pressures in fissured rock masses for evaluating and controlling leakage through dam abutments and foundations, and providing stability evaluation parameters. This research is a continuation of previous studies in which a detailed review was made of permeability measurement methods, seepage characteristics, and analyses applicable to rock masses. This continued research plan is based largely on the results, conclusions, and recommendations presented in the final report, "Determination of Rock Mass Permeability," by Timothy W. Zeigler, TR S-76-2, January 1976, U.S. Army Engineer Waterways Experiment Station Vicksburg, Miss. The research program involves test equipment development, controlled laboratory and field testing, field observations, and theoretical analyses to accomplish the following tasks:

Task I: Development and/or modification of water and air pressure test equipment, test procedures, and interpretation methods for measuring permeability, and evaluating seepage and uplift pressures in fissured rock masses.

Task II: Determine the applications and limitations of water and air pressure tests and the interrelation of measured permeability parameters, rock type, fissure characteristics, seepage, and uplift.

Task III: Determine the applications and limitations of the frequently used continuum (i.e., continuous porous medium) and the recently developed discontinuum (i.e., discontinuous fissured medium) analysis methods for evaluating and/or predicting seepage and uplift conditions in rock masses.

314-11526-360-00

IMPROVED OUTLET WORKS TRAJECTORIES

(*c*) G. A. Pickering.

(*e*) Objective is to develop the most efficient trajectory shape for given flares of sidewalls in outlet works transitions. With low and intermediate flows in outlet works stilling basins, problems are being encountered with eddies formed in the basin that cause severe abrasive damage to the basin apron and elements. These problems result from the inability to maintain a stable hydraulic jump in the transition between the conduit and stilling basin. Problems are also being encountered with flow distribution in transitions with high discharges, especially with flow from oblong conduits. Tests will be conducted with various shapes of conduits to determine the optimum shape of trajectory for various flare ratios to insure good pressure conditions and distribution of flow into the stilling basin. The tests facility will consist of circular, rectangular, and oblong conduits connected to a headbay. Flow into the conduit will be regulated by one or both slide gates, with the capability for various heads on the gates and Froude numbers of flow in the conduits.

(*g*) The experimental facilities were designed and constructed during FY 78. Tests have been conducted with circular conduits to measure the under nappe profile of the jet as it leaves the conduit for various heads or discharges. Construction of the rectangular and oblong tests sections were completed.

314-11527-360-00

GENERAL OUTLET WORKS STILLING BASIN TESTS

(*c*) G. A. Pickering.

(*e*) Objective is to develop practical guidance for design of outlet works stilling basins and downstream protection. Many reservoir outlet works stilling basins operate through a range of discharge where the tailwater elevation is well above that required for the formation of a hydraulic jump. The resulting submerged jump conditions frequently cause flow to concentrate downstream of the stilling basin and results in severe scour downstream from the structure. Extensive channel armoring is then required to maintain the

structural integrity of the exit area and the stilling basin. Concurrent with the development of optimum trajectory shapes in 314-11526-360-00, systematic physical model tests will be conducted to determine the interrelated and necessay hydraulic and geometric characteristics required to provide satisfactory performance in outlet works stilling basins and adjacent exit channels for a wide range of Froude numbers of flow and tailwater elevations.

(*g*) Construction of a 1:16-scale model of an existing outlet control structure experiencing severe flow concentration and scour in the downstream exit channel was initiated during FY 78. After field inspection of this problem, it was decided that this is a fairly typical prototype that operates daily and provides good opportunity for comparison and correlation between model and prototype. Tests to define velocities at various positions within and downstream of highly submerged stilling basins were initiated in an existing flume. The results indicate that tailwater depths greater than 1.1 times the theoretical sequent depth required to create a hydraulic jump concentrate rather than diffuse flow.

314-11528-700-00

IMPROVED RIVER VALLEY CROSS-SECTION DATA COLLECTION PROCEDURES

(*c*) B. O. Benn.

(*e*) The objective of this study is to investigate methods for reducing the cost of acquiring and using geometric data in hydraulic studies. The results will provide more uniform guidance for specific cross-section data requirements as a function of basin characteristics and products desired from hydraulic/hydrologic simulation procedures, and recommendations for data handling techniques that will streamline the acquisition and handling of cross-section data for Corps studies. Stream hydrology/hydraulics calculations are of major importance in the Corps District's activities. The trend to more streamlined and standardized data acquisition and calculation procedures can allow this function to be accomplished in a more cost effective manner. The acquisition and preparation of cross-section data is one of the most costly aspects of hydrology/hydraulics studies. Any procedures which could result in a substantial reduction in the direct costs of obtaining cross-section data and reductions in costs associated with subsequent data manipulations should be investigated. Criteria for the selection of cross-section locations can be improved on the basis of flow simulation accuracy requirements, computer model restraints, and basin geometry. These criteria can then be used to develop guidelines for establishing minimal cross-section density, optimal location, length, and alignment. Also, improved and expanded use of automated data handling procedures can be implemented. As an absolute minimum, software packages for transforming conventional field survey data to a form suitable for direct input to hydraulic models and suitable formats for recording conventional field survey data for this purpose can be developed. A brief survey of current Corps District cross-section data acquisition and handling practices will be made. The survey will focus on criteria used to design field data collection programs, locating sites for cross-section measurements, field data acquisition procedures, data handling techniques and associated times and costs for these times. Guidelines will be established to determine minimum cross-section density and accuracy requirements through the use of sensitivity analyses with the program HEC-2. A desk-top study will be made to recommend automated data handling techniques that will streamline the acquisition and handling of cross-section data. Recommendations will be made concerning the advantages and disadvantages of the Corps' current cross-section data acquisition handling techniques and the potential of alternative systems for collecting and handling those data. Recommendations for the field evaluation of selected airborne- and ground-data collection systems will also be set forth.

314-11529-330-00

EFFECT OF SUBMERGENCE AND DRAFT ON LOCK OPERATION

(*c*) G. A. Pickering.

(*e*) Objective is to provide information as to the effect of submergence and vessel draft on recommended operations of low and high lift types of lock filling and emptying systems and provide guidance for optimal elevation of lock gate sills. Locks are generally the bottleneck in a navigation system. Submergence (distance between lock floor and the bottom of the vessel), draft and clearance of the bottom of the vessel over lock gate sills have a definite effect on safe and efficient entry and exit of lock chambers, filling and emptying operations, and acceptable hawser forces. If the time required for the passage of each tow can be reduced by faster entry and exit, the individual lock, as well as the system capacity will be increased. 1:20-scale models of three typical high-lift locks, two typical low-lift locks and several representative tows and towboats will be used to determine the interrelated effects of submergence, vessel draft, and drag forces encountered in entering and exiting operations required for safe and efficient lockage along inland waterways. Chamber widths of 84 ft and 110 ft and lengths of 600 ft and 1200 ft will be investigated.

314-11530-330-00

HYDRAULIC DESIGN OF GROINS AND DIKES

(*c*) T. J. Pokrefke.

(*e*) Objective is to develop design criteria for use in selecting the stone spur dike characteristics needed for a particular application to constrict or stabilize a low-water navigation channel for maximum efficiency and minimum environmental effect. A study of existing dike designs indicates a wide variance in the design parameters used. These parameters are based primarily on the experience of the engineer, because no general design criteria have been developed. Some stone dike design parameters, such as side slope and crest width, are relatively consistent while parameters such as dike spacing, dike height, angle in relation to the direction of flow, and crest profile are not consistent. The approach to this study includes: (a) a review of published literature and USAE Division and District experiences and current practices concerning the design of stone spur dikes; (b) model test spur dike parameters which include height, spacing, angle in relation to the direction of flow, and crest profile; and (c) publish design guidance in the form of Engineer Technical Letters and Engineer Manuals.

(*g*) The literature survey was completed. A symposium was held at WES in March 1978 to review the current field practices on the design of stone spur dikes.

314-11531-330-00

EFFECTS OF WIND AND WAVES ON NAVIGATION AT ENTRANCE CHANNELS

(*c*) G. A. Pickering.

(*e*) Objective is to develop effective criteria for maintenance of entrance channels to assure safe navigation conditions. Coastal channels have generally been designed by "rule-of-thumb" estimates because there are no experimentally or theoretically based procedures to guide these efforts. This frequently results in oversizing of channels relative to the traffic requirements, plus additional maintenance of the channel. Improved design and maintenance requires a much better understanding of the effect of environmental factors such as wind, waves and current on vessel behavior. Analytical and physical model studies will be used to develop criteria for design and maintenance of entrance channels. The test facility being used in 314-10759-330-00 will be used for the study. Tests will be conducted with simulated wind and waves of various magnitudes from a number of directions to determine what effect this has on the maneuverability of ships of different sizes at a number of different speeds. These data will be used to determine the size of entrance channels required for safe and efficient navigation.

(*g*) A wave generator was designed and constructed in FY 78.

314-11532-300-13

COMPOSITION OF THE MISSISSIPPI RIVER

(*b*) New Orleans District.

(*c*) M. P. Keown.

(*e*) The objective of this work is twofold, i.e., to: (a) characterize the suspended-sediment regime of the Mississippi River in consideration of land-use practices and completion of river control structures, and (b) investigate changes that have occurred in the composition of the riverbed material since 1930. The approach is divided into three phases as follows:
Phase 1. Locate pertinent records related to the suspended-sediment regime and bed-material composition of the Mississippi River and for those tributaries and distributaries that influence the regime and composition (completed April 1978).
Phase 2. Collate the information located in Phase 1 into a qualitative description of the suspended-sediment regime and bed-material composition of the Mississippi River. Quantitative descriptions will be developed for reaches where sufficient data are available (to be completed July 1979).
Phase 3. Prepare documentation on the work conducted during Phases 1 and 2 (to be completed October 1979).

314-11533-310-13

AUTOMATED SYSTEM FOR FLOOD DAMAGE ASSESSMENT

(*b*) Lower Mississippi Valley Division.

(*c*) V. E. LaGarde.

(*e*) The objective of this study is to provide area flooded as a function of river stage for the Lower Mississippi Valley to be used in the LMVD Flood Damage Estimation System. The area flooded-river stage calculations will be performed as a function of water resource unit and land use.

(*g*) Four Districts (New Orleans, Vicksburg, Memphis, and St. Louis) within LMVD provided USGS topographic base maps with Water Resource Units (WRU) delineated. Personnel at WES and LMVD interpreted land-use classes (cleared, forested, urban, water, and other) from color infrared aerial photographs enlarged from a scale of 1:120,000 to 1:62,500. Contour data, WRU boundaries and land-use data were digitized and placed into the master computer-based information file. Analyses were performed to produce acres flooded versus stage for each land use.

314-11534-310-00

WOLF RIVER EXPANDED FLOODPLAIN INFORMATION STUDY

(*c*) J. K. Stoll.

(*e*) Objectives are to develop more generally applicable and improved analytical systems for conducting hydrologic, economic, and environmental studies of large river basins; to simulate flow regimes of selected recurrence interval floods on the Wolf River and its major tributaries for both present (1976) and anticipated future (2025) land-use conditions; to estimate economic damages and certain environmental consequences of selected recurrence interval floods on the Wolf River and major tributaries for present and future land-use conditions; to investigate the effects of selected variables on flow regimes. The river basin will be divided into "subbasins," which delineate the watershed area of major tributaries to the Wolf, and into "minibasins," which delineate watershed areas of secondary and tertiary tributaries and/or small areas (i.e., 1 to 10 mi sq with narrowly varying hydrologic characteristics. Two computerized data bases will be developed–a 200 m gridded base for the entire basin containing slope, soils, and hydrologic-related land-use categories and a 50 m base encompassing all floodplain areas containing elevation and economic land-use categories. All basin data are to be supplied by the Memphis Engineer District, Soil Conservation Service, and other governmental agencies. Software will be developed to extract necessary information from the 200 m data base and a cross-section data base to drive hydraulic (HEC-2) and hydrologic (HEC-1) computer models. In turn, output from these models and information extracted from the 50 m data base and a point structure data base will be used to drive WES models developed for the computation of flood depths and economic damages. Sensitivity studies will be conducted on some subbasins to establish the effects of selected variables (e.g., roughness coefficients, runoff coefficients, land use, hypothetical storm type, etc.) on flow regimes. The study results will be documented in report form; user manual type documents will be prepared to assist future users of the analytical system.

314-11535-310-13

TENSAS RIVER STUDY

(*b*) Vicksburg District.

(*c*) H. Struve.

(*e*) The objectives of this study are as follows:
(1) To determine for the years 1941, 1951, 1956, 1960, 1964, 1969, 1972, 1975, 1977, and 1978 the total acreage of forested and nonforested areas in three Parishes (East Carol, Madison, and Tensas) of the Tensas River Basin.
(2) To determine for the years 1941, 1951, 1956, 1960, 1964, 1969, 1972, 1975, 1977, and 1978 the area of forested and nonforested lands associated with each one-foot elevation change in five reaches of the Tensas River Basin.
Forested and nonforested areas are to be delineated from ASCS photography for the years 1941 thru 1969 and from Landsat for the years 1972 thru 1978. Primary elevation data are to be obtained from USGS topographic maps. The elevation and land-use data are then to be digitized for analysis by the computer. The computer analysis will provide the mensuration data required to satisfy the objectives of this study.

314-11536-710-13

REMOTE SENSING METHODOLOGY FOR SEEPAGE DETECTION

(*b*) New Orleans District.

(*c*) W. K. Dornbusch.

(*e*) Objective is to develop an expedient detection capability for seepage along the Mississippi River levee system. Methodology for seepage detection to be developed over a multiyear period and incorporated in a technical report as a final product for dissemination to district offices where seepage is a serious problem during floods.

(*g*) A remote sensing package was flown over selected portions of the Mississippi River levee in the New Orleans District (on the east bank between Burnside and St. Gabriel) during flood stages in 1975. The missions were flown by the Earth Resources Laboratory/NASA at times during flood stages on the river determined to be optimum by the WES. Both camera and scanner (IR) data were taken. The photography was manually interpreted to identify problem areas. The scanner data will provide input to the development of a completely computerized methodology which will expediently identify areas of seepage and thereby permit elimination of manual interpretaiton and ground surveillance during flood periods. Ground truth will be taken by WES personnel to permit quantitative correlation with the remotely sensed data. While data from future missions will be required to finalize a methodology no future missions are scheduled within the NOD due to financial and logistical constraints. Remaining funds will be directed to the preparation of a final report based on the analysis of mission data from the NOD and VED study areas. Future missions in VED are dependent upon the occurrence of a spring flood fulfilling research requirements. No effort has been directed towards the project since the spring 1975 flood.

314-11537-300-13

SAFETY OF MAIN-LINE MISSISSIPPI RIVER LEVEES

(*b*) Lower Mississippi Valley Division.
(*c*) V. H. Torrey III.
(*e*) Objective is to complete a study initiated by LMVD in October 1969 to establish criteria for evaluating the safety of Mississippi River main-line levees based on current soil mechanics practice. Completed work will be reviewed on studies of (a) past levee slides, (b) stability of typical levee sections and foundations composed of various soil strata determined from selected borings, and (c) adequacy of levee sections and needed changes in design criteria. Criteria for identifying potentially unstable reaches of existing levees will be developed.

314-11538-310-13

ARTIFICIAL FLOOD WAVES IN YAZOO BASIN

(*b*) Vicksburg District.
(*c*) W. A. Thomas.
(*e*) Objective is to use existing mathematical models to calculate maximum flood depth, rate of flood wave movement, duration of flooding and width of flooded area for artificial floods from Arkabutla, Enid, and Grenada Reservoirs. Cross sections will be coded to develop a numerical model of the Yazoo Basin from Greenwood, Miss., to the upstream end of Arkabutla Reservoir including both Enid and Grenada Reservoirs. Calculations will then be made to define the outflow hydrograph and to route the flood wave downstream for different failure conditions at each project. Three initial reservoir conditions will be evaluated at each project.
(*g*) Enid Reservoir to Greenwood geometry has been digitized and debugged. Base flow is being established at near-bank-full discharge prior to executing the artificial flooding tests.

314-11539-300-13

CALCULATION OF DYNAMIC LOOP EFFECT ON MISSISSIPPI RIVER

(*b*) Lower Mississippi Valley Division.
(*c*) C. J. Huval.
(*e*) Objective is to implement a dynamic stage-discharge numerical model for unsteady discharge calculations. The model will then be applied to the 1973 flood using the Vicksburg, Helena, and Baton Rouge gaging stations. The model result will be used to compute the dynamic loop effect for the project design flood flowline on the Mississippi River. River geometrical and flood data were obtained for the three gaging stations. The model was modified to allow variable Manning's n values on rising and falling hydrographs. The model was then calibrated to the 1973 flood data at the gaging stations. Two design flood hydrographs were then used to study the dynamic loop magnitude at the three representative river stations.
(*g*) The computations have been completed and a draft report prepared. Review comments have been received from the sponsor and the report forwarded for publication.

314-11540-300-13

LEVEE WAVE WASH PROTECTION BY TREES

(*c*) D. D. Davidson.
(*e*) Objective is to determine the wave attenuation effectiveness of a selected tree scheme for protection of river levees. Two-dimensional flume tests will be conducted for various tree band widths of a selected pattern and spacing of trees to determine the wave attenuation effectiveness of the entire scheme. The study includes testing two tree diamters at still-water levels representing both the tree trunk section and the tree branch sections.
(*g*) All tests have been completed and Vicksburg District has approved the final report for publication. Preparation of the final report is in progress.

314-11541-440-13

LAKE PONTCHARTRAIN HURRICANE BARRIER STUDY

(*b*) Lower Mississippi Valley District.
(*c*) R. W. Whalin.
(*e*) Objective is to evaluate the effect of the Lake Pontchartrain and vicinity hurricane protection plan on the tidal prism, circulation, hurricane surge levels, and water quality in Lake Pontchartrain. Prototype tide, velocity and wind data will be acquired to verify a numerical tidal circulation model of the Lake Pontchartrain and vicinity. Prototype water quality data (temperature, conductivity, and dissolved oxygen) also will be collected. Physical models will be used to quantify volume transport through and head losses across the Seabrook and Chef Menteur structures. A numerical hurricane surge and coastal flooding model will be used to evaluate effects of barrier plans on hurricane surge flooding.
(*g*) Prototype tide, velocity, and wind data necessary for verifying the physical models of Seabrook and Chef Menteur have been collected and analyzed. Prototype data necessary for verification of the numerical tidal circulation model also have been collected and are being analyzed at the present time. Meteorological data used as input to the hurricane surge model are being evaluated and work has been initiated on the numerical hurricane surge model. Work on the formulation of the numerical tidal circulation model is well underway. Construction of the physical models of the Seabrook and Chef Menteur structures is completed and model verification has been initiated.

314-11542-300-13

EFFECTS OF OVERBANK VEGETATION–MISSISSIPPI BASIN MODEL

(*b*) Lower Mississippi Valley Division.
(*c*) J. E. Foster.
(*e*) Objective is to investigate the effects on flood heights of increasing and decreasing the vegetation on the overbank areas between the levees and the channel. Tests were conducted on the St. Louis to Cairo Reach of the Mississippi Basin Model, a fixed-bed model of the Mississippi River and its tributaries to a horizontal scale of 1:2000 and a vertical scale of 1:100.
(*g*) Tests have been completed. Data is being prepared for inclusion in the report.

314-11543-750-13

MODEL-PROTOTYPE COMPARISON STUDY, MISSISSIPPI RIVER

(*b*) Lower Mississippi Valley Div.
(*c*) L. J. Shows.
(*e*) Objective is to conduct a model-prototype comparison study to determine the degree of agreement between model predictions and prototype performance. The study is being conducted using prototype data collected at eight different reaches along the lower Mississippi River to compare to results obtained during model tests of the same reaches with the dike systems in place.
(*g*) Report in preparation.

314-11544-220-00

MOVEMENTS OF DREDGED MATERIAL

(*e*) Objective is to develop techniques for determining the spatial and temporal distribution of dredged material discharged into various hydrologic regimes. Through field investigations determine critical erosion velocity, shear stress, and modes of sediment transport for four sediment mixtures.
(*f*) Complete.
(*h*) **Flume Experiments on Sand, Silt, and Clay Mixtures from the Offshore Dredged Material Disposal Site, Galveston, Texas, *TR-D-78-34*, June 1978.**

314-11545-870-13

NORFORK LAKE TEMPERATURE STUDY

(*c*) B. Loftis.

(*e*) Objective is to simulate the effects on water temperature within and released from Norfork Lake with two hydropower alternatives: one additional conventional unit, or two additional pumpback units. A mathematical model adapted from the Marysville Lake Study is being used to predict water temperatures. Three years of data were used to calibrate and verify the model. Alternative conditions will be modeled and resulting temperatures determined.

(*g*) Calibration of the numerical model is complete.

U.S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS, NATIONAL ENGINEERING LABORATORY, CENTER FOR MECHANICAL ENGINEERING AND PROCESS TECHNOLOGY, FLUID ENGINEERING DIVISION, Washington, D.C. 20234. Dr. G. E. Mattingly, Division Chief.

315-07243-060-20

MEASUREMENT OF LEE WAVE DRAG ON SPHERES

(*b*) Office of Naval Research, Dept. of the Navy.

(*c*) Mr. Karl Lofquist, Physicist, and Dr. L. P. Purtell.

(*d*) Experimental and theoretical; basic research.

(*e*) Measurement of difference in drag between sphere moving in linearly stratified salt water and in fresh water.

(*f*) Experiments completed. Report in preparation.

315-08652-700-00

OPEN CHANNEL FLOW MEASUREMENTS

(*c*) G. Kulin, Hydraulic Engineer.

(*d*) Experimental; basic and applied.

(*e*) To develop liquid velocity measurement standards and provide flow measurement support to Government and industry. To evaluate and improve flow measuring instruments and procedures needed in water pollution control and devise means for transferring flow measurement capability from laboratories to field users. To investigate turbulence effects on bucket-type current meters. To evaluate the performance of rotating element current meters at velocities lower than those at which they are routinely calibrated and under conditions encountered in velocity-area traversing of small conduits for flowrate determination. To evaluate procedures for field calibration of measuring flumes, weirs and other devices by current meter traverses and by other methods, and to identify and quantify errors caused by improper installation of those instruments.

(*g*) A low-turbulence 24-inch diameter water tunnel has been completed, with velocity range from 0.1 to 20 ft per second. A three-dimensional numerical model for Parshall flume flow was developed.

(*h*) **A Numerical-Experimental Study of Parshall Flumes,** R. W. Davis, S. Deutsch, to appear in *J. Hyd. Res., IAHR*.

315-09731-020-52

STRUCTURE OF TURBULENCE

(*c*) P. S. Klebanoff, NBS, and F. N. Frenkiel, DTNSRDC, Carderock, Md.

(*d*) Experimental, and analytical, basic research.

(*e*) To develop and devise measurement techniques incorporating analog and digital methods for the measurement of the statistical properties of turbulence, and to provide significantly new data which will extend our knowledge of turbulent processes. The microstructure of turbulence will be investigated using hot-wire instrumentation and high-speed computing methods. Analog recordings of turbulent data are made on multi-channel magnetic tape for a turbulent field established in the NBS wind tunnel. The analog data is digitized and analyzed at DTNSRDC. Both isotropic and anisotropic turbulent fields will be studied with special emphasis being given to the flow downstream of a turbulence producing grid and in a turbulent boundary layer. However, apart from the forementioned investigation, which is carried out in collaboration with NSRDC, there is, in addition, an investigation of the relatively unexplored turbulence structure of low Reynolds number turbulent boundary layers which will be studied using laser velocimetry and hot-wire anemometry.

(*g*) Higher-order moments of the gradient of the longitudinal velocity fluctuation were measured at higher free stream turbulence levels. The higher free stream turbulence was created by fluttering aluminum tags attached to a 1-inch mesh grid. The results obtained at the higher free stream turbulence were in good agreement with those obtained at lower turbulence levels. Measurements of the higher-order moments of the gradient of the longitudinal velocity fluctuation in a turbulent field downstream of a grid in the 3-ft water tunnel at DTNSRDC were completed, These also showed the same behavior of the higher-order moments.
Further measurements were made using a probe to measure simultaneously the three components of turbulent velocity fluctuations. Higher-order moments of gradients of transverse velocity fluctuations have been obtained. Measurements of mean velocity distributions and skin friction coefficients have been made down to a Reynolds number based on momentum thickness of 450. It is planned to investigate whether a characteristic turbulent boundary layer can be obtained at a still lower Reynolds number.

(*h*) **On The Lognormality of The Small-Scale Structure of Turbulence,** F. N. Frenkiel, P. S. Klebanoff, *Boundary Layer Meteorol.* **8,** 2, p. 173, 1975.
Grid Turbulence in Air and Water, F. N. Frenkiel, P. S. Klebanoff, T. Huang, *Physics of Fluids* **22,** 9, p. 1606, Sept. 1979.
The Turbulent Boundary Layer at Low Reynolds Number, L. P. Purtell, P. S. Klebanoff, F. T. Buckley, Paper (in preparation). L. P. Purtell's *Ph.D. Thesis*, University Microfilms International Catalog No. 79-06663.

315-09732-250-50

DRAG REDUCTION

(*b*) National Aeronautics and Space Administration, Langley Research Center; Office of Naval Research, Fluid Dynamics Program.

(*c*) Drs. P. S. Klebanoff and J. M. McMichael.

(*d*) Experimental and analytical, basic and applied research.

(*e*) Determine the feasibility of obtaining drag reduction by the use of compliant boundaries. The investigation will be conducted on a specially designed flat plate in the 5-ft x 7-ft test section of the NBS dual-test section wind tunnel. The compliant surface under investigation consists of a 1 mil thick aluminized mylar film stretched over a 3/16-inch thick, 40 ppi, open-cell polyurethane foam substrate. Parameters that are varied are the lateral and longitudinal tensions of the film, and the free-stream velocity. Overall surface drag is determined by a specially designed balance. A similar investigation is also being carried out in water using the NBS water tunnel that has a test section, 2 feet in diameter and 10 feet long. The investigation in water also requires that provision be made for obtaining overall surface drag by a direct method, albeit it must be of different design than that in air.

(*g*) The investigation of the compliant surface in air is nearing completion. This study involved a direct comparison of the overall surface drag of the compliant surface with that for a rigid reference surface. The measurements carried out with the rigid reference surface consisted of overall skin friction over a range of air speeds, detailed mean velocity and turbulence intensity distributions within the boundary layer, and a detailed evaluation of the "gap" effect. The latter arises from having a floating panel mounted within a much larger plate. These detailed measurements were made to demonstrate not only internal consistency but the accuracy of the methods. Overall skin friction drag mea-

surements were also carried out for the compliant surface over a range of air speeds for varying lateral and longitudinal tensions of the membrane. The surface motions of the membrane were also monitored. The primary results of this phase of the investigation were presented at the Symposium on Viscous Drag Reduction helt November 7, 8, 1979, at Dallas, Texas. The NBS water tunnel has been made operational and its performance has been evaluated. It is a facility well suited for a compliant surface investigation. The boundary layer plates and reference surface have been constructed and await installation in the tunnel. A method for measuring overall skin friction drag has been designed and constructed. This method consists of a flexure balance and is different from the air-pressure balance designed for the wind tunnel investigation. A traversing mechanism to permit measurement of the pressure distribution along the plate and boundary layer characteristics has been designed and construction drawings are in progress. Various compliant surfaces are being looked into to determine their suitability for testing.

(*h*) **An Experimental Investigation of Drag Reduction by a Compliant Surface,** J. M. McMichael, P. S. Klebanoff, N. E. Mease (paper in preparation).

315-10780-410-11

OBSERVATIONS OF OSCILLATORY SAND RIPPLES

(*b*) Coastal Engineering Research Center.
(*b*) K. E. Lofquist, Physicist.
(*d*) Experimental.
(*e*) Observation of the initiation, growth and final stable forms of oscillatory sand ripples in relation to given wave and bed parameters.
(*f*) Completed.
(*g*) Previous results that the size of two-dimensional equilibrium ripples is proportional to the amplitude of the water flow were confirmed and extended. New results were obtained regarding the development and growth of ripples and the variability of their final forms.
(*h*) **Observations of Oscillatory Sand Ripples in a Water Tunnel,** K. E. Lofquist, *CERC Tech. Paper TP 78-5*, Aug. 1978.

315-10789-750-00

MATHEMATICAL MODELING FOR DYNAMIC VOLUME MEASUREMENTS

(*c*) Dr. R. W. Davis.
(*d*) Theoretical.
(*e*) The objective of this project is to improve dynamic volume measurement capabilities by providing a basic understanding of the performance of closed-conduit measuring devices. The most important immediate objectives are to determine the effects of swirling flow on various types of measuring devices and to design an optimum upstream flow conditioner to improve the devices' reliability.
The current almost complete lack of knowledge concerning the internal workings of dynamic volume measuring devices is causing severe measurement uncertainty problems in American industry. Flow meter manufacturers and oil and gas pipeline users are among those who are concerned about this and who will benefit from this study. The NBS goal of dynamic volume measurement assurance will be aided by this project. Improvements in measurement accuracy related to fluid volume transfer will lead to more equitable usage and pricing in such areas of national concern as energy (e.g., natural gas prices).
Our approach here is to use mathematical modeling (in conjunction with carefully planned validation experiments conducted under (315-10793) in order to completely analyze the flowfields inside closed-conduit dynamic volume measuring devices operating under realistic conditions. Effects of changes in the operating environment of these devices (particularly the poorly understood target meter) will be assessed, with specific attention given to swirl effects. An attempt will be made to design an axially symmetric upstream flow conditioner which will minimize the effects of environmental changes on the measuring device. We currently have several computer codes with proven reliability available. These will be used and modified as required. New codes will be added as necessary.
(*g*) Using support from a related project, a turbulence modeling code (TEACH) developed at Imperial College, London, England, was obtained, modified and validated. This code was used to simulate turbulent flows through orifice meters operating under realistic conditions.
Currently work is proceeding on successors to the TEACH code. These utilize higher-order differencing schemes in order to provide and enhance accuracy at high Reynolds numbers. The unsteady flow around vortex-shedding meters is presently being studied. Also various techniques, including fundamental solution methods, are being tested on a new model problem of swirling pipe flow which contains a moving shear layer.
(*h*) **Numerical Solutions for Turbulent Swirling Flow Through Target Flowmeters,** R. W. Davis, E. F. Moore, G. E. Mattingly, R. W. Miller, *Paper 78-WA/FM-4*, presented ASME Winter Annual Meeting, San Francisco, Calif., 1978.
Numerical Modeling of Swirling Laminar Orifice Flow, R. W. Davis, E. F. Moore, presented *IMEKO Symposium on Flow Measurement and Control in Industry*, Tokyo, Japan, Nov. 1979.

315-10790-700-27

EXPERIMENTAL VALIDATION FOR MODELING A UVT

(*b*) U.S. Air Force, Wright-Patterson.
(*c*) Dr. G. E. Mattingly.
(*d*) Applied, theoretical.
(*e*) Design, construct, and perform an experiment to produce the required data to validate a mathematical model of a particular Universal Venturi Tube (UVT) in conjunction with conventional calibration data. The essential feature of the validation is to document any flow characteristics in the meter which would improve the performance of critical density and temperature instrumentation located downstream of the UVT.
The UVT meter will be one of four such meters used to measure flow in the USAF's new Compressor Research Facility being built at the Wright Patterson Air Force Base. The planned experiment will establish traceability to NBS for the flow measurement made at this facility.
An extensive calibration will be done for a scaled model of the particular meter. In addition, for three flows spanning the range of the meter, detailed velocity profile and pressure distribution measurements will be made and compared to results obtained by mathematically modeling this flow field.
(*g*) A scaled model of the particular meter is presently under test at NBS. Auxiliary equipment needed for the velocity and pressure measurements has been designed and is being built.

315-10791-700-00

INTERLABORATORY FLOW METER TEST

(*c*) Dr. G. E. Mattingly.
(*d*) Applied; experimental.
(*e*) As a preliminary step in establishing Flow Measurement Assurance Programs (MAPs), an interlaboratory flow meter test program has been conducted using small, momentum-type meters in water flows. Five laboratories, including NBS, voluntarily participated in setting up a test procedure which was designed to quantify interlaboratory agreement, or indicate the nature of variability that may exist among laboratories.
(*g*) Several rounds of tests have been conducted with the results appropriately reported to the participants. Anonymity of participants, testing details, and the results

have been preserved as per the agreement desired by the participants until unanimous agreement is reached for making these items known. Limited expansion of the initial group of participants has incorporated one additional American laboratory and one foreign national laboratory.

(*h*) By agreement with participants, the report on the test and the results shall be limited to distribution only among the participants.

315-10792-700-00

AUTOMOTIVE EXHAUST FLOWMETER

(*c*) Dr. B. Robertson.
(*d*) Applied; experimental and theoretical.
(*e*) Develop and evaluate an essentially nonintrusive flowmeter for use along with existing real-time pollutant concentration detectors for measuring pollutant emissions from automobile tailpipes in real time. The flowmeter will be used on automobile production lines and in local testing stations to verify compliance with EPA regulations. It will also be used for engine testing. At present there is no flowmeter that can measure exhaust gas flow. The flowmeter uses a new long wavelength acoustic principle which requires a loudspeaker and two microphones just inside a pipe. Electronic circuitry is used to produce the appropriate frequencies at the loudspeaker and to process the microphone signals to obtain an output proportional to the volume flow rate of the exhaust.
(*g*) A preliminary version of the flowmeter was constructed and tested. The results suggested modifications which have been incorporated in a new design. Preliminary evaluation of the new technique indicates that it will be successful. Seven printed circuit boards required for a prototype flowmeter have been completed, wired together, and tested.
(*h*) **Effect of Arbitrary Temperature and Flow Profiles on the Speed of Sound in a Pipe,** *J. Acoust. Soc. Am.*, Oct. 1977.
Synchronous Marker for Measuring Phase in the Presence of Noise, B. Robertson, J. E. Potzick, *Rev. Sci. Instrum.* 48, pp. 1290-1294, 1977.

315-10793-750-00

LDV MEASUREMENTS OF VELOCITIES AND TWO POINT CORRELATIONS

(*c*) Dr. B. Robertson.
(*d*) Applied; experimental.
(*e*) Laser Doppler velocimeter measurements of the velocity profiles of water flowing through various flowmeters and pipeline elements for comparison with the predictions of the mathematical model (see 315-10789). The results will be useful in designing new flowmeters and pipeline elements and in improving existing ones in order to obtain more accurate flow measurements under adverse conditions. Hydrogen bubbles released in isolated bursts from a wire across the flow will be used for flow visualization prior to the LDV measurements. The bubbles are electrochemically generated by applying 600 volt pulses to the wire. Future plans include other flowmeters and other pipeline elements and also two point correlation measurements using a dual LDV and a dual-channel signal processr.
(*g*) A new two-probe LDV system has been designed that will be able to measure the cross correlation of the turbulent velocities in two independently movable 1 $mm^2 \times 4$ mm volumes.

315-10794-700-00

BULK MEASUREMENT OF NUCLEAR FUEL

(*c*) Dr. J. A. Simpson.
(*d*) Experimental, applied.
(*e*) Develop and disseminate measurement methodology for bulk measurements in nuclear fuel plants, validate measurement procedures for in-plant flow meters and evaluate the usefulness of reference standards to enhance the safeguard system.
Acountability of special nuclear materials, often called Safeguards, has attracted the attention of all levels of Government. It impacts on proliferation, possible terrorism and on the form of the future world-wide nuclear industry. It appears that energy demands of the future will require the completion of the fuel cycle and the resultant increase in production of special, i.e., weapon quality, nuclear material. The measurement of bulk quantities is central to any system of physical accountability.
Existing measurement technology will be adapted and combined with well-established Measurement Assurance techniques to validate the measurement systems *in situ* as they are realized in industry. Selected commercial components will be evaluated and knowledge of their characteristics combined with appropriate measurement methodology to enhance measurement methods as used in the field.

315-10795-700-00

SAFEGUARD: BULK MEASUREMENT METHODOLOGY

(*c*) Dr. J. A. Simpson.
(*d*) Experimental, applied.
(*e*) A well-characterized measurement methodology for bulk measurements, adequate for the control of special nuclear materials, will be developed.
Accountability of special nuclear materials, often called Safeguards, has attracted the attention of all levels of Government. It impacts on proliferation, possible terrorism and on the form of the future world-wide nuclear industry. It appears that energy demands of the future will require the completion of the fuel cycle and the resultant increase in production of special, i.e., weapon quality, nuclear material. The measurement of bulk quantities is central to any system of physical accountability.
Current bulk measurement methods, based on over-simplified concepts and equipment designed according to NBS HB44, has been time consuming and only marginally adequate. The approach is to assemble selected commercially available components into systems which optimize the performance of the components, thereby improving bulk measurement capabilities. The activities include (1) density and temperature corrections for fluid volume determination via simulated process tanks, (2) dynamic volume measurements, and (3) mobile meter testing facility.
(*g*) Planning and early design stages were completed for special purpose equipment that will be acquired to conduct experiments.

315-10796-700-00

FLUID MECHANICAL MEASUREMENTS

(*c*) P. S. Klebanoff.
(*d*) Basic research; theoretical and experimental.
(*e*) To improve the technical base for fluid mechanical measurements, and provide the technical data and the extended measurement services required by the nation's technology.
Flow processes involving the measurement of air and water velocity play important roles in such areas of national concern as health and safety, energy and the environment. Public awareness has focused on problems associated with the discharge of pollutants into the atmosphere, and the nation's water resources, the occurrence of water shortages, and the air flow to be maintained in connection with industrial ventilation. As a result more stringent requirements have developed for the accuracy of air and water velocity measurements, and improved measurement methods for steady and turbulent flows. All surface water flows in nature and most wastewater flows occur as open-channel flows, yet many charac-

teristics of these flows need to be better defined. Improved water flow measurements are therefore needed not only for water measurement and control, but also to further the understanding of the flow process itself. Regulations concerned with health and safety have also imposed requirements for extending the range and precision of air velocity measurements. Concomitantly, all flows important to the environment, and many aspects of the nation's technology are turbulent, imposing a need for a competence in turbulence measurement, and an understanding of the effect of turbulence on fluid mechanical instrumentation.

By theoretical analysis and experimental evaluation achieve an improved understanding of the performance of aerodynamic and hydraulic instrumentation. This incorporates developing methods for describing the properties of free-surface flows, with emphasis on partly full circular channels, developing capabilities for improved low velocity measurements in air and water, investigating the effect of turbulence on the performance of anemometers and water current meters, and by analog and high speed digital computing techniques improve instrumentation and methods for turbulence measurements.

(*g*) Progress was hampered by the fiscal situation and although work on some aspects had to be delayed, substantive progress was made in a number of areas. A survey of available information on flow in part-full circular pipes was completed. The publication, "Hydraulic Research in the United States and Canada, 1976," was prepared and edited. A modification to the NBS laser velocimeter was completed which decreased the standard deviation of the individual particle velocities in the averaging process by a factor of five.

A calibration capability for the dynamic response of anemometers has been established. The experimental phase of an investigation concerned with the nonlinear spectral characteristics of a helicoid anemometer has been completed. The first draft of a report describing the NBS Unsteady Flow Facility has also been completed.

(*h*) **The Dynamic Response of Helicoid Anemometers,** J. M. McMichael, P. S. Klebanoff, *NBSIR 75-772*, Nov. 1975.

315-10797-700-34

ANEMOMETER PERFORMANCE AT LOW VELOCITIES

(*b*) Bureau of Mines.
(*c*) L. P. Purtell.
(*d*) Applied research.
(*e*) Evaluate the behavior of anemometers considered for mine use at low-flow velocities. The Federal Coal Mine, Health and Safety Act of 1969 (Public Law 91-973, December 30, 1969) authorizes the Secretary of the Interior to establish flow velocity requirements for mine ventilation, and to designate appropriate instrumentation for such measurments. The Mine Enforcement and Safety Administration (MESA) of the Department of Interior, established in 1972, has the responsibility for establishing and enforcing the regulatory standards for appropriate mine ventilation procedures. A major difficulty, in the past, in establishing flow velocity standards was the lack of a capability to evaluate the performance and applicability of existing and new instrumentation for the measurement of very low air velocities. The development of the NBS Low-Velocity Airflow Facility has provided this capability and enabled NBS to respond to the need of the Bureau of Mines and MESA.

Using the low-velocity facility, and the recently developed laser velocimeter, an experimental evaluation will be conducted of the behavior of standard and prototype air speed measuring instruments as a function of previously characterized low-velocity air flows. Particular emphasis will be given to the speed range 10 ft/min to 600 ft/min. The instruments will be supplied by the Bureau of Mines. Also to meet the needs of the Department of the Air Force, the feasibility of designing a scaled-down version of the NBS Low-Velocity Airflow Facility will be investigated.

(*g*) Six instruments that may serve as possible transfer standards have been evaluated. These instruments consisted of four anemometers of the vane type, a vortex shedding anemometer, and a vane deflection anemometer. A draft of a typical instrument evaluation report has been prepared and is presently being iterated with the Bureau of Mines as to the final format. It is planned to continue with the evaluation of other types of instrumentation for mine use.

315-10798-010-27

BOUNDARY LAYER CONTROL

(*b*) Arnold Engineering Development Center.
(*c*) P. S. Klebanoff.
(*d*) Experimental.
(*e*) To improve the performance of compressible flow wind tunnels as laboratory instruments for obtaining reliable test and design data.

The transition from laminar to turbulent flow in boundary layers is one of the important problems in fluid mechanics, and an important design parameter for aeronautical and aerospace vehicles. The present state of affairs is such that no reliable design data on transition can be obtained from model tests in compressible flow wind tunnels. This has raised significant questions as to the adequacy of compressible flow tunnels for such measurements. With the many millions of dollars invested in such facilities such a limitation is naturally of great concern, but more important is the lack of adequate design data. Apart from the fact that transition test results in the laboratory cannot be extrapolated to flight conditions, the present situation is such as to prevent the proper study and development of laminar flow control methods for reducing drag and heating on vehicle components, and inhibits fundamental research on boundary layer stability and transition. A number of major technical meetings, both national and international, have been held on the subject, and a study group has been established with the sponsorship of the Air Force. The result has been that improving the performance of ground based facilities has become a high priority objective.

Two aspects of the problem are being investigated. One which has been under investigation for a number of years is to determine the feasibility of laminarizing boundary layers in the test sections of compressible flow tunnels by using suction. This aspect utilizes the NBS Mach 2, 3-inch by 4-inch tunnel. The other is the effectiveness of boundary layer "trips." Involved herein is a fundamental study, at incompressible flow speeds, of the behavior of three-dimensional roughness elements in inducing transition.

(*g*) Using an adjustable-tapered-rodded sidewall, laminar boundary flow has been achieved over practically the entire sidewall at a stagnation pressure of one atmosphere corresponding to a Reynolds number per inch of 0.3×10^6. At stagnation pressures above one atmosphere the degree of laminarization begins to deteriorate apparently due to increased sensitivity to surface irregularities. An adjustable-rodded nozzle block that minimizes these irregularities has been designed and constructed. Apart from the fact that it has been designed to minimize surface irregularities, the NBS design of the nozzle block represents a new departure from traditional nozzle block design. In tests carried out to date, laminarization of the boundary layer and the rodded nozzle block has been achieved up to the Mach 2 test chambers. In connection with that aspect concurrent with the study of roughness elements, all aspects of the experimental setup have been completed. A 4-1/2 foot by 12-foot flat plate has been aligned in the wind tunnel. A false wall was mounted on the wind tunnel wall opposite the working side of the plate and adjusted to give zero pressure gradient along the plate. Transversing equipment has been constructed and installed and all appropriate instrumentation, including hot-wire and mean-

velocity probes, have been assembled. The necessary background measurements of the boundary layer associated with the transition on the flat plate without roughness are nearing completion.

315-11724-410-11

OBSERVATIONS OF DRAG ON NATURALLY RIPPLED SAND BEDS UNDER OSCILLATORY FLOWS

(*b*) Coastal Engineering Research center.
(*c*) Mr. Karl Lofquist, Physicist.
(*d*) Experimental; basic research.
(*e*) Measurement of combined skin and profile drag on naturally rippled sand beds in an oscillatory-flow water tunnel. The drag is obtained as function of time and from which rates of average energy dissipation are computed.

U.S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS, NATIONAL ENGINEERING LABORATORY, CENTER FOR MECHANICAL ENGINEERING AND PROCESS TECHNOLOGY, THERMOPHYSICAL PROPERTIES DIVISION, Boulder, Colo. 80303. J. Hord, Acting Division Chief.

316-07005-110-00

CRYOGENIC FLOWMETERING

(*b*) Joint NBS-AGA Pipeline Research Committee.
(*c*) Mr. J. A. Brennan, Mechanical Engineer.
(*d*) Experimental; applied research.
(*e*) Determine performance of flowmeters under controlled cryogenic conditions, investigate new flow measurement methods, provide transfer standard calibrations, determine flowmeter performance in LNG.
(*g*) The facility is operational and is being modified to include room temperature gas flow capability.
(*h*) **Transfer Standards in Cryogenic Flow Measurement,** J. A. Brennan, C. H. Kneebone, E. Kenkins, *Flow Measurement of Fluids, Proc. FLOMEKO 1978*, Sept. 11-15, 1978.
On a New Method of Gas Flow Measurement Using Cryogenic Techniques, D. B. Mann, J. A. Brennan, *Flow Measurement in Open Channels and Closed Conduits* **2,** pp. 881-893, *NBS Spec. Pub. 484*, Oct. 1977.

U.S. DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, GREAT LAKES ENVIRONMENTAL RESEARCH LABORATORY, 2300 Washtenaw Avenue, Ann Arbor, Mich. 48104. Dr. Eugene J. Aubert, Director.

317-10668-440-00

WATER MOVEMENTS AND TEMPERATURE

(*c*) Dr. D. B. Rao.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) Develop improved climatological information on the distribution and variability of currents and temperatures and to study their dependence on meteorological and hydrological forces.
Develop and test improved numerical hydrodynamic models that can simulate and predict the temperature and current distributions in the Lakes.
Develop and test improved models to simulate and predict the transport and diffusion of pollutants and to participate in coupling these models to aquatic ecology and water quality models. A hierarchy of such numerical models of different complexities will be developed and tested for use as tools in water resources planning.
Improve the understanding of physical processes occurring in the lake by analyzing data and the results from the numerical models.
(*h*) **Comparison of Airborne Radiation Thermometer and Buoy Temperature Measurements,** R. L. Pickett, S. Bermick, *IFYGL Bull. 14:76*, 1975.
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317-10669-440-00

SURFACE WAVES AND WATER LEVEL FLUCTUATIONS

(*c*) Dr. D. B. Rao.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) Improve climatological information on the distribution and variability of surface waves, wind set-ups, surges, and seiches.
Develop improved theoretical and empirical models for the above phenomena for prediction purposes.
Develop models for the atmospheric boundary layer above the Lakes to provide the necessary input into the above prediction models.
Improve understanding of the physical processes involved so that numerical models can be improved.
(*h*) **Baroclinic and Barotropic Edge Waves on a Continental Shelf,** D. L. Cutchin D. B. Rao, *Special Report No. 30*, prepared by the Dept. of Energetics and Center for Great Lakes Studies, the University of Wisconsin-Milwaukee, 1976.
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317-10670-810-00

HYDROLOGIC PROPERTIES

(*c*) Dr F. H Quinn.
(*d*) Experimental and theoretical; applied research.
(*e*) Develop a hydrologic data base of sufficient quality for both scientific and water resource studies of the Great Lakes. Parameters to be included are precipitation, runoff, ground water, evaporation, connecting channel flows, changes in lake storage, and beginning-of-month lake levels.
Develop improved numerical models to predict and simulate the water levels and flows through the Great Lakes system. Models to be developed include hydrologic response models of the entire system, hydraulic transient models for the connecting channels, water supply prediction models, and watershed hydrologic models.
Develop improved understanding of the hydrologic processes of the Great Lakes Basin as they relate to objective (2) above.
Provide a Great Lakes advisory service on water supply parameters, water levels, and flows.
(*h*) **Lake Erie Terrestrial Radiation,** J. A. Derecki, *Water Resources Research 12(5):979-984*, Oct. 1976.
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U.S. DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, OFFICE OF OCEANIC AND ATMOSPHERIC SERVICES, NATIONAL WEATHER SERVICE, Silver Spring, Md. 20910. Dr. Robert A. Clark, Associate Director, National Weather Service (Hydrology).

318-10671-300-00

RIVER MECHANICS RESEARCH ON UNSTEADY FLOWS

(*c*) Dr. Danny L. Fread, Research Hydrologist, Hydrologic Research Laboratory.
(*d*) Theoretical and field; applied research.
(*e*) Investigations are conducted to develop improved operational forecast mathematical models of one-dimensional unsteady flow in rivers, reservoirs, and estuaries. Models are developed which simulate the effects of: 1) upstream and downstream wave propagations, 2) short circuiting of flows in flood plains with meandering rivers, 3) stream-aquifer interactions, 4) dam-break flood waves, 5) variable hydraulic resistance to flow, 6) flow interactions in river systems, 7) sediment transport, 8) ice jams, and 9) transport and dispersion of oil and chemical spills. The models' computational efficiency, numerical accuracy, simulation accuracy, calibration requirements, and data input requirements are investigated in an effort to develop models having optimal characteristics.
(*g*) An efficient and flexible implicit finite difference solution of the one-dimensional equations of unsteady flow has been developed to form the basis of an operational model for predicting stages and discharges in rivers and estuaries. The model has powerful data handling features and has been successfully tested on the Ohio-Mississippi Rivers and the lower Columbia River. An efficient automatic calibration algorithm has been developed to calibrate the variable flow resistance of the one-dimensional unsteady flow model. The model has special algorithms for efficient

simulation of flows in river systems, flood plains with meandering rivers, and flows through locks and dams. A special dam-break flood forecasting model has been developed and tested. The model generates the dam-break flood hydrograph and simulates the propagation of the flood wave through a downstream valley which can have additional dams located along the course of the valley.

(*h*) **The Development and Testing of a Dam-Break Flood Forecasting Model,** D. L. Fread, *Proc. Dam-Break Flood Modeling Workshop*, U.S. Water Resources Council, Oct. 1977, NTIS PB-275437.

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U.S. DEPARTMENT OF ENERGY, Argonne National Laboratory (see Argonne National Laboratory listing).

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U.S. DEPARTMENT OF ENERGY, Bonneville Power Administration, P.O. Box 3621, Portland, Oreg. 97208. Martin J. Lavelle, Head, Power Capabilities Section, Power Resources Branch, Power Management Division.

319-11443-340-00

RIVER AND RESERVOIR THERMAL EFFECTS FROM COMBINED HYDRO–THERMAL GENERATION

(*c*) William L. Morse, Mathematician, Power Capabilities Section.

(*d*) Theoretical, basic, and applied research.

(*e*) A stochastic thermal conservation equation is formulated and solved as a random nonlinear Volterra integral equation. Solutions from a fairly new method, due to J. B. Keller (New York University), are compared with those obtained deterministically and by statistical simulation. This random integral equation model provides water resource planners with a more economic forecasting tool in which to determine stream temperatures in probability during critical climatic or river flow conditions.

(*f*) Suspended.

(*h*) **The Dishonest Method in Stream Temperature Modeling,** *Water Resources Research, 14(1), 45-51*, 1978.

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U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION, DIVISION OF RESEARCH, Attention 1530, Denver Federal Center, Denver, Colo. 80225. Howard J. Cohan, Division Chief. (Address all inquiries to Attn: 1530.)

321-06321-340-00

DRAFT TUBE SURGES

(*d*) Theoretical and experimental; basic and applied research.

(*e*) Surging flow in draft tubes of Francis turbines causes rough operation resulting in unbalanced loads on the turbine runner and often produces power swings. The surging is produced by excess angular momentum in the flow entering the draft tube. The purpose of the project is to investigate the basic nature of surging, to correlate model and field test data, and investigate means of reducing the magnitude and range of the surging.

(*g*) A 229-mm scale model of Grand Coulee units 22, 23, and 24 has been tested to evaluate the unstable ranges of turbine operation. The swirl-momentum method for predicting the surging range of operation is being modified to obtain better agreement with test results. A computer simulation employing the method of cascades is being used to obtain the direction of flow leaving the wicket gates and should provide a more accurate wicket gate momentum parameter. Air injection tests have been completed on the model turbine and will be used to define operational ranges where air injection can reduce surging. Model and prototype data are presently being evaluated to determine the degree of conformance.

(*h*) Report in preparation.

321-07022-340-00

GRAND COULEE PUMP-TURBINE INTAKE AND TRANSITION

(*d*) Experimental; for modification.

(*e*) Laboratory studies are continuing to determine the benefits which could be derived by lowering the floor of the Banks Lake Feeder Canal.

(*f*) Completed.

(*g*) The conduit exits, designed and built for pumped flow only, must be modified to operate satisfactorily as inlet-outlet structures for the pump-turbine concept. A satisfactory design developed by model study included reshaping 78 feet of the conduit exits, and adding one vortex-suppressing wing wall.

(*h*) Report in preparation.

321-07028-350-00

AUBURN SPILLWAY GATE STUDY

(*d*) Experimental; design.

(*e*) A 1:24 scale model was used to study the rectangular bellmouth entrance, downstream seal fixed-wheel gate, gate frame, and the conduit through the dam.

(*f*) Completed.

(*g*) The entrance shape produced positive pressures throughout its length. An elliptical frame which protruded into the flow downstream from the gate slots was developed to prevent cavitation damage in the frame area. An aeration offset downstream from the gate frame was developed to allow the jet to be aerated on all surfaces before reaching the sloping conduit. A slope was established for the downstream conduit to prevent filling of the bottom aeration offset for all heads and gate openings encountered. Hydraulic downpull data was obtained for the gate to place seal contact blockouts to eliminate areas of unstable vertical forces.

(*h*) Report in preparation.

321-07030-320-00

CANAL AUTOMATION

(*d*) Experimental development; applied research.

(*e*) Continue the development of controls for automatic flow regulation of canal systems.

(*g*) The EL-FLO plus RESET method of automatic downstream control continues to operate two canal systems in California. Equipment reliability has not been very satisfactory to date. Work continues to modify equipment to improve reliability. The development of prototype equipment for the "set-operate-variable-rest" method for the diversion dam outlet works continues. Prototype equipment is being field tested and performance has been satisfactory. Work has been started to apply microprocessor-based equipment for the automatic control of check gates and outlet works. The development of the "Harder-Smith Predictor Method" (HSPM) for automatic downstream control of canal check gates continues. The HSPM is a highly responsive control system. A research contract with the University of California at Berkeley with Professor J. A. Harder as principal investigator has been completed with the exception of the final report. The practicality of the HSPM has yet to be verified. A study was completed and a report written for an automatic upstream control system utilizing the proportional plus proportional reset (P+PR) mode of control for the bypass drain check gates of the Yuma Desalting Plant. The application of the P+PR control system can automatically

transfer all degrees of drainage inflow changes from upstream to downstream and return the water levels (upstream of canal check structures) back to desired target levels within a reasonable period of time.

(*h*) **Study of Electronic Filter Level Offset (EL-FLO) plus RESET Equipment for Automatic Downstream Control of Canals**, C. P. Buyalski, E. A. Serfozo, *REC-ERC-79-3* (in preparation) and **Study of an Automatic Upstream Control System for Canals**, C. P. Buyalski, *GR-78-4*, *Aug. 1977*.

321-07035-350-00

AUBURN DAM SPILLWAYS

(*d*) Experimental; design.

(*e*) A 1:72 model is used to study flow conditions in the chutes, stilling basins, and river channel. The service spillway is located on the left abutment and discharges into a hydraulic jump stilling basin. The emergency spillway on the right abutment terminates in a flip bucket. Each spillway discharges up to 160,000 cfs through controlled orifices located up to 150 feet below the maximum water surface. The model is also being used to determine optimum sequencing of the orifices.

(*f*) Completed.

(*g*) Tests confirmed that the hydraulic jump energy dissipator for the service spillway was satisfactory. Testing was continued to develop alternate means for distributing the flow from the service spillway. Efforts have been directed toward terminating the chute about midway between the orifice spillway and the river channel. A flip-type bucket was developed to deflect the flow into an excavated plunge pool in the river channel.

(*h*) Report in preparation.

321-09380-340-00

TWIN LAKES PUMPED STORAGE PROJECT

(*d*) Experimental; design.

(*e*) Two models were used to determine the effect of the pumping and generating flow on a natural lake used as the afterbay during the generating cycle and forebay for the pumping cycle. A distorted model (1:100 vertical - 1:600 horizontal) was made of the recipient lake and a connected companion lake which was thermally stratified and the effect of several weeks of plant operation on the stratification was determined. The second model was undistorted on a 1:100 scale and contained the pumping-generating plant and a section of the recipient lake. This model was to determine the best configuration for the channel between the plant and lake to prevent the flow from disturbing glacial flow deposits on the bottom of the lake.

(*f*) Completed.

(*g*) An alinement for a channel between the pumping-generating plant and the lake was developed that withdrew water from middepth in the lake during the pumping cycle and influenced the inflowing jet during the generating cycle so that it had less tendency to move along the bottom of the lake. Flow was well distributed across the channel as it entered the lake during the generating cycle. During the pumping cycle the flow entered the channel along the left bank of the lake but was evenly distributed by the time it reached the plant. The glacial flour deposits on the bottom of the lake should not be disturbed by plant operation. This configuration had only minor influence on temperatures and stratification in the lower lake.

(*h*) Report in preparation.

321-09382-350-00

STEWART MOUNTAIN DAM SPILLWAY

(*d*) Experimental; design.

(*e*) A 1:72 model is used to evaluate the influence of high tailwater caused by a proposed downstream dam and to evaluate various problems that have resulted due to recent spillway releases. The spillway has a 265-foot-wide, radial gate controlled crest. The spillway chute contains a superelevated horizontal curve. The spillway does not have a stilling basin structure. In addition to the hydraulic effects of the high tailwater, training wall overtopping that results under specific operating conditions, spillway discharge capacity, and downstream channel modifications are being studied.

(*g*) Very high tailwater eliminates the influence of the chute superelevation and results in severe training wall overtopping.

321-09383-360-00

LOW FROUDE NUMBER STILLING BASINS

(*d*) Experimental, applied research.

(*e*) Studies were done to develop a generalized hydraulic jump stilling basin for Froude numbers between 2.5 and 4.5. The design was very effective and incorporated chute blocks, baffle piers, and a dentated sill. Dimensionless ratios were developed for basin length, size, and location of the appurtenances in the stilling basin. These data will supplement the USBR Monograph No. 25, **Hydraulic Design of Spillways and Energy Dissipators.**

(*f*) Completed.

(*h*) **Low Froude Number Stilling Basin for Spillway Flows**, R. L. George, *Report REC-ERC-78-8*, Aug. 1978.

321-09384-390-00

ICE RESEARCH

(*d*) Experimental, field research.

(*e*) To improve designs and to reduce expenses of operating and maintaining water resource projects in cold regions. Present areas of investigations include frost action, ice jam observations, coatings to reduce ice adhesion, and development of a supercooled water temperature measuring device.

(*g*) The temperature measuring device has been developed and is being tested prior to planned field applications.

(*h*) **Winter Ice Jam Observations on the Gunnison River**, P. H. Burgi, *Report REC-ERC-79-4*, Feb. 1979.

321-09385-210-00

HORIZONTAL MULTIJET SLEEVE VALVE

(*d*) Basic research; development.

(*e*) The multijet sleeve valve has potential for use in pressure systems of municipal and industrial water supply lines for dissipation of pressure heads up to 500 feet. The investigation involves sizing the multijet ports and stilling chamber and determining the discharge coefficients for the valve and stilling chamber.

(*f*) Completed.

(*g*) A multijet sleeve has been developed where a combination of nozzles and slots are used to efficiently pass the design flow.

(*h*) **Hydraulic Tests and Development of Multijet Sleeve Valves**, P. H. Burgi, *REC-ERC-77-14*.

321-09388-850-00

McCLUSKY CANAL FISH SCREEN

(*d*) Experimental; design.

(*e*) Two full-scale section models are being and will be used to study the performance of a fish screen structure designed to stop the passage of fish, fish eggs, and fish larvae. The prototype structure will filter a discharge of 1950 ft^3/s. One model is being studied in the laboratory where screen filtration capability, rubber seal effectiveness, and structure size optimization are being considered. A cursory evaluation of self-cleaning properties and of potential cleaning devices is also being conducted. Live and preserved fish eggs and larvae are being used in the laboratory tests. The other model will be tested at a field site near the canal. These tests will primarily evaluate operations and maintenance problems including screen cleaning, biological fouling, debris handling, and corrosion. Various screen materials will be used in these tests.

(*g*) A 70-mesh or finer woven screen is required to meet filtration requirements. Hydraulic tests have yielded a rela-

tionship between required screen area, discharge, and screen orientation.

321-09390-220-00

CONTROL OF TURBIDITY AT CONSTRUCTION SITES

(*d*) Experimental; applied research.
(*e*) A study team was assembled to review current methods and techniques currently used for control of turbidity at construction sites. Research projects will be conducted in areas related to turbidity control where information is lacking.
(*g*) Ongoing research and factual information concerning turbidity and presently used methods of measurement and control of turbidity were assembled. A report is being prepared which will be made available to planners, designers, construction engineers, and other field construction personnel.
(*h*) **Control of Turbidity at Construction Sites,** USBR, Dec. 1977.

321-09391-840-00

FLOW INTO INTERCEPTOR DRAINS ON SLOPING LAND NOT INSTALLED PERPENDICULAR TO THE WATER TABLE GRADIENT

(*d*) Experimental; applied research.
(*e*) Field experience has shown that agricultural drains installed on an angle not perpendicular to the water table gradient are not effective when installed according to criteria for drains on level land. A 60-foot long, 2-foot wide, 2-1/2 foot-deep sand tank whose slope can be adjusted up to 12 percent will be used to determine adjustments in drain spacing that are necessary.
(*g*) Tests with drains at 0°, 30°, 45°, and 90° angles to hydraulic gradient with gradient slopes up to 10 percent have been tested.
(*h*) Report in preparation.

321-09393-350-00

HYDRAULIC MODEL STUDIES OF PALMETTO BEND DAM SPILLWAY

(*d*) Experimental; for design.
(*e*) Hydraulic model studies aided in the design of the inlet channel to the spillway, the stilling basin, and the channel downstream from the spillway.
(*f*) Completed.
(*g*) Tests with a 1:100 scale overall model resulted in verification and slight changes to the initial design. The inlet channel was widened and a bend of the inlet channel placed further upstream. To improve flow entering the left side of the spillway a dike was placed upstream from the dam along the left side of the inlet channel. Length of the stilling basin was reduced by 30 feet and elevation of the floor raised 5 feet. Also it was found beneficial to add floor blocks and a dentated end sill to the stilling basin. Water flowed from the stilling basin onto a flood plain. Embankments were placed on each side of the stilling basin downstream for a 400-foot distance to channelize water leaving the spillway. The embankments prevented excessive circulation eddies near each end of the stilling basin. Because of the low Froude number stilling basin a 1:30 scale sectional model was used to finalize the design of the floor blocks and dentated end sill.
(*h*) **Hydraulic Model for Palmetto Bend Dam Spillway,** E. R. Zeigler, *GR-78-8*, Nov. 1978.

321-09394-840-00

DRAIN ENVELOPE STUDIES

(*d*) Applied research.
(*e*) A corrugated plastic drain tube, surrounded by a gravel envelope, was hydraulically tested and test results compared to an electrical analogy study. Present gravel envelope head loss design criteria are based on test results of the electrical analogy study, which did not simulate turbulent flow.
(*f*) Completed.
(*g*) Turbulent flow occurred for the hydraulic tests, but for discharges greater than normally occur with field drains. Flow through the gravel envelope for the hydraulic tests was 30 times greater than indicated by the electrical analogy study. This difference was caused by nonhomogeneity of the gravel envelope medium in the hydraulic tests. The gravel did not completely fill corrugations of the plastic drain tubing and large particles formed stratifications in the envelope. Water more readily flowed through the less dense portion of the gravel envelope than current through the uniformly resistive conductor of the electrical analogy tests.
(*h*) **Hydraulic and Electrical Analogy Tests of Gravel Envelopes for Subsurface Drains,** E. R. Zeigler, *GR-78-7*, May 1978.

321-10672-210-00

CORRUGATED PLASTIC DRAIN TUBING

(*d*) Applied research.
(*e*) Friction, grade deviation, and limited sedimentation tests were made using an 18-m (60-ft) length, 100-mm (4-in) diameter, nonperforated corrugated plastic drain tube. Four bends, 2.4 m (8 ft) long, with one- and two-tube diameter offsets above and below grade, formed the grade deviations; and a fine uniform 0.2-mm mean diameter sand was used for the sedimentation tests.
(*f*) Completed.
(*g*) Manning's "n" varied from 0.015 to 0.016 for full-tube flow and from 0.015 to 0.018 for free-surface flow. Only with bends above grade, and for conditions of free-surface flow, was the hydraulic gradeline seriously affected. The hydraulic gradeline raised upstream from the bend, approximately the amount of the bend offset. The sediment did not prevent waterflow through a two-diameter offset bend below grade, with a 0.001 slope of the straight tubing.
(*h*) **Hydraulic Laboratory Manning's *n* and Grade Deviation Study for 4-inch Diameter Nonperforated Corrugated Plastic Drain Tubing,** E. R. Zeigler, *REC-ERC-78-2*, Feb. 1978.

321-10674-350-00

ABRASIVE MATERIALS IN STILLING BASINS

(*d*) Applied research.
(*e*) Some stilling basins have required expensive repairs because of abrasive materials circulating with the water. These materials entered the basins in different ways; water circulation at the downstream end of the basin draws rock into the basin, rock and debris thrown in by spectators, and/or debris left by the contractor. Hydraulic model studies may show design changes that will provide better flushing and lessen the tendency for material to be drawn from downstream into the basin. A survey was made of the Review and Maintenance records that were kept for Bureau of Reclamation stilling basins to determine which structures have abrasion problems. Another objective of the study was to determine whether the material entered by man or flowing water, if by flowing water from what source, the location and extent of damage, and operating conditions causing the damage.
(*f*) Completed.
(*g*) One type stilling basin susceptible to abrasion problems is the combined basin, where the spillway and outlet works discharge into the same basin. Much of the time only the outlets operate and the valves release singular jet flows into the basin. Large eddy patterns can form, causing rocks to roll around the basin floor and in some instances the eddy extends past the basin and the return flow brings rocks into the basin. Hollow-jet valve outlet works basins can experience abrasion damage. The Bureau's two largest basins had severe surging near the bottom at the end of the basin. Rocks were hydraulically carried into the basin and the violent energy dissipation action "ball milled" the rocks against the concrete, exposing the steel reinforcing bars. Outlet works type II basins with high-head slide gate controlled inflows were another category of basins which experienced abrasion. Information from the surveyed

records could not prove that rocks were hydraulically pulled into the basin, but this is a possibility. The records did show rocks had been thrown in by the public. However, rocks once in the basin remained and damaged the basin floor. In most instances these basins operated at less than 70 percent of the maximum design discharge. The study recommended that hydraulic model tests should be made for this category of basins, and careful attention paid to discharge conditions less than maximum.

321-10675-350-00

CURECANTI DROP PIPE, SPIRAL FLOW INTAKE, AND STILLING BASIN

(*d*) Experimental; for design.
(*e*) A 1:22.5-scale model was made of the 142-m-high drop structure to develop a spiral flow intake to force the flow to cling on the wall of the 2286-mm-diameter vertical pipe and to provide satisfactory stilling basin.
(*g*) The intake dropped the flow at 55° and converged at 15° on both sides to form a tangential slot 0.305 metres wide. The flow remains spiral for about 40 metres. The remaining fall is straight but the flow clings to the wall. The stilling basin was about 5 metres deep and long. A wave suppressor was needed to dampen wave action.
(*h*) Report in preparation.

321-10676-350-00

BLANCO DIVERSION DAM

(*d*) Experimental for rehabilitation design.
(*e*) A 1:16-sediment model was used to develop a sediment excluding system to prevent coarse sediment from abrading the diversion tunnel and to make sluicing operations less obtrusive downstream. A large portion of the sediment gradation was scaled to account for armoring.
(*f*) Completed.
(*g*) A trapping system requiring more frequent sluicing of smaller quantities of sediment was developed. The trapping system reduced tunnel sediment intake by about 25 percent.
(*h*) Report in preparation.

321-10677-350-00

KLANG GATES DAM

(*d*) Experimental for design of modification to enlarge reservoir capacity.
(*e*) A 1:36-scale model was used to determine if the spillway and stilling basin would still be adequate after adding four top-seal radial gates to increase the maximum reservoir elevation about 7 metres.
(*f*) Completed.
(*g*) Pressure measurements indicated no excessively low pressures. Calibrations were provided for the gates which were located just downstream of the ogee crest. Optimum gate operations for one- and two-gate combinations for low discharges were determined.
(*h*) Report in preparation.

321-10678-320-00

HYDRAULIC STUDIES OF STEEP CANAL LATERALS

(*d*) Experimental; applied research.
(*e*) Small, unreinforced, concrete-lined, trapezoidal cross-section canal laterals with maximum flow velocities less than 5 m/s and with maximum discharges less than 1 m^3/s are often used on irrigation projects. The grades of these laterals of concern tend to follow the ground surface and, thus, flow velocities vary. Both subcritical and supercritical flows may occur in the same lateral reach. Studies are being conducted to evaluate wave heights developed by undular hydraulic jumps and by grade changes and to evaluate uplift pressures that develop under the lining, at lining breaks, and offsets.
(*g*) For a lateral with 1-1/2 to 1 side slopes and for specific instantaneous grade changes a relationship between flow velocity at the toe of the grade change, discharge, and resulting wave height has been developed.

321-10679-860-00

DESTRATIFICATION DIFFUSER EFFICIENCY TESTS

(*d*) Field investigation; applied research.
(*e*) A 210-metre-long compressed air line diffuser is being operated at a $3 \times 10^8 m^3$ reservoir. Total energy input from the diffuser, reservoir dissolved oxygen levels, reservoir temperature distributions, and other physical, chemical, and biological properties of the reservoir are being closely monitored. Historical records of reservoir temperature and DO profiles prior to diffuser operation are available. The objective of the study is to develop relationships between destratification and reoxygenation efficiencies and unit air flow rate from the line diffuser. Two seasons of field data have been collected.
(*g*) Field operation and data reduction continue.

321-10681-350-00

POT HOOK MORNING GLORY SPILLWAY

(*d*) Experimental; design.
(*e*) A 1:24-scale hydraulic model was used to develop a morning glory spillway design. The maximum discharge for the spillway will be 145 m^3/s. Approach flow conditions to the spillway crest, vortex suppression, pressures on the crest, shaft, and vertical bends, tunnel deflectors, air demand, and approach flow conditions to the stilling basin were evaluated.
(*f*) Completed.
(*g*) Tests developed vortex suppression piers that yielded good tunnel flow conditions while maintaining a satisfactory coefficient of discharge for the crest.
(*h*) Report in preparation.

321-10683-350-00

PACHECO

(*d*) Experimental; applied research.
(*e*) A 1:11.54 hydraulic model of the high pressure slide gate and stilling basin was constructed and tested to develop a satisfactory design for these components of the Pacheco tunnel. The discharge of the tunnel could vary from less than 1.1 m^3/s (40 ft^3/s) to 13.6 m^3/s (480 ft^3/s). The maximum head on the slide gate was 73.8 m (242 ft) of water. The effect of the high velocity discharge from the slide gate was studied.
(*f*) Completed.
(*g*) The control structure of the Pacheco tunnel is a 1.52-m × 2.14-m (5-ft × 7-ft) high pressure slide gate with a stilling basin immediately downstream. The initial design performed satisfactorily except for subatmospheric pressures downstream from the control gate and on the energy dissipator baffle piers. The subatmospheric pressures occurred only for heads above 67.1 m (220 ft) of water and gate openings between 3 and 8 percent. An elliptical section 152 mm (6 in) wide was placed on both sidewalls donwstream from the gate slot, which raised the pressures downstream from the gate. Also, the bypass was enlarged to a 508-mm (20-in) pipe so that the gate would not be required to operate at gate openings less than 5 percent open. The potential cavitation pressures measured on the original round-top baffle pier were minimized by using a modified flattop baffle pier, which resulted in pressures only slightly below atmospheric.
(*h*) **Hydraulic Model Studies for the Pacheco Tunnel Energy Dissipator, R**. L. George, *Report GR-18-76*, Sept. 1976.

321-10684-350-00

CHOKE CANYON

(*d*) Experimental, applied research.
(*e*) A 1:80-scale model was used to study the stilling basin and the approach channel to the spillway. The spillway will be about 112 metres wide and will have a maximum discharge of 7100 m^3/s. A stilling basin was designed according to the criteria developed for low Froude number stilling basin and is being tested in the model.
(*f*) Completed.
(*h*) Report in preparation.

321-10685-340-00

PENSTOCK ENTRANCE RESEARCH

(*d*) Experimental; applied research.
(*e*) Hydraulic model studies are being conducted to aid in the development of design criteria for economical, efficient penstock entrances.
(*f*) Suspended.

321-10686-390-00

CLAMSHELL GATE

(*d*) Experimental; development.
(*e*) Studies are being made to develop a gate for both free and submerged releases which is free of cavitation damage within the valve body. The clamshell concept arose from the need to eliminate gate slots or elaborate shaping while providing a well directed jet with a large discharge coefficient.
(*g*) Tests have been completed on the gate for free releases. Some preliminary tests have been performed on the gate discharging submerged. An energy dissipator to stabilize the flow will be added to the tailbox to increase the range of discharges at larger gate openings. Tests with small partial openings have been completed for heads up to about 30 meters.

321-10688-820-00

GRAVEL PACKS AND WELL SCREENS FOR WATER WELLS

(*d*) Experimental; applied research.
(*e*) A 4.88-m (16-ft) deep, full-scale, simulated water well has been constructed in the hydraulic laboratory to test gravel packs and well screens. Forty-five piezometers were installed on five levels to measure pressures inside the well screen in the gravel pack and in the base aquifer material. A full-scale pump and piping system recirculates water from a sump, through the aquifer and gravel pack, into the well. Discharge is measured with a magnetic flowmeter. A mini (MAC) computer system is used to obtain data rapidly and store it on magnetic tape.
(*g*) One hundred seven steady pumping, plant surging, and surge block surging tests have been completed with discharges of approximately 1.0 to 10.0 L/s.

321-10689-370-47

BICYCLE SAFE GRATE INLETS

(*b*) Federal Highway Administration.
(*c*) P. H. Burgi, Code 1531.
(*d*) Experimental; development.
(*e*) Slotted drain grate inlets are currently being studied. Hydraulic tests for selected conditions have been completed. A general hydraulic design method covering a range of possible slot installations is being developed.

321-10692-360-00

BAFFLED SPILLWAY ENERGY DISSIPATOR

(*d*) Experimental; for design.
(*e*) Laboratory studies were performed to develop a baffled spillway to be used when conventional energy dissipators might not be appropriate due to marginal siting conditions.
(*f*) Completed.
(*g*) Test determined that the design criteria used for the canal drop type baffled aprons with a limiting unit discharge of 5.6 m^3/s per metre of width (60 ft^3/s per foot of width) could be extrapolated to a spillway use with a unit discharge of 28 m^3/s (300 ft^3/s or greater. Construction difficulties and physical size of the structure seem to be the only limiting conditions.
(*h*) **A Baffled Apron as a Spillway Energy Dissipator,** T. J. Rhone, *J. Hydraulics Division, ASCE* **103,** HY12, Dec. 1977.

321-11444-300-00

EFFECTS OF HYDRAULICS ON BANK STABILITY CAUSED BY THE GRAND COULEE THIRD POWERPLANT EXTENSION OPERATION

(*d*) Experimental research and analysis for project modification.
(*e*) A 1:120 model is being used to determine boundary shear and size of material that will move during powerplant operation. Transient tests simulating unit operations and load rejections are being made.
(*g*) Transient tests indicate that compensation flows to prevent large floodwaves can cause gravity waves near the dam and the design of the bank should be based on wave design methods. Analysis and field data are required to determine how far downstream shear and velocity design methods alone are adequate.
(*h*) Report in preparation.

321-11445-350-00

MCPHEE DAM CHUTE SPILLWAY

(*d*) Experimental, design.
(*e*) A 1:36-scale model is being used to develop a design for the approach channel, chute spillway and combination stilling basin-flip bucket for McPhee Dam. The approach channel will be cut in the right abutment of the dam. The chute spillway will be 18 meters wide and 228 meters long. Energy will be dissipated in a hydraulic jump stilling basin for flows up to the 100-year flood (377 m^3/s). Larger flows (up to 938 m^3/s) will be flipped into the downstream channel with a flip bucket at the end of the stilling basin.
(*f*) Testing is underway.

321-11446-340-52

LOW-HEAD HYDROPOWER, STANDARDIZATION OF FLOW PASSAGE DESIGN

(*b*) Department of Energy.
(*d*) Applied research.
(*e*) A literature search has been done to determine the present state-of-the-art in flow passage design and standardization of flow passages for low-head hydroelectric structures. The purpose of the research is to determine if it is possible to reduce costs of low-head structures by standardizing the design of flow passages. Additional work has been proposed to study the effect of changing intake and draft tube configurations on hydraulic efficiency.
(*h*) Report in preparation.

321-11447-130-00

AIR-WATER FLOWS IN HYDRAULIC STRUCTURES

(*d*) Theoretical; applied research.
(*e*) A state-of-the-art literature review was conducted of air-water flow conditions in hydraulic structures. The types of structures considered include open channels, closed conduits, vertical shafts, gates and valves discharging into closed conduits, pipelines, and penstocks. When possible, the divergent results were unified through a common theory.
(*f*) Completed.
(*g*) Design guidelines were developed for a wide range of air vent applications. A method for predicting the mean air concentration in open channel flow is given, computer programs to predict air flow rates during emergency gate closures on penstocks and to predict the water surface profiles and air concentration on spillways and chutes were developed.
(*h*) **Mean Air Concentration of Self-Aerated Flows,** H. T. Falvey, *Tech. Note, J. Hydraulics Division, ASCE* **105,** HY-1, Jan. 1979, pp. 91-95. (Two reports and a paper in preparation.)

321-11448-350-00

GATE STROKING

(*d*) Theoretical; applied research.

(*e*) Gate stroking is a continuous or a series of discontinuous gate motions which produce a predetermined water surface variation in a canal. The technique was conceived by Professor E. B. Wylie at the University of Michigan. The present study investigates the application of the technique to an aqueduct system which includes transitions, inverted siphons, tunnels, check gates, and trapezoidal canal sections. A computer listing and description are included in the report.
(*f*) Completed.
(*g*) The method proved to be a very successful method for remotely-controlled operation of large aqueducts.
(*h*) **Gate Stroking**, H. T. Falvey, *REC-ERC-79-7*, 1979.

321-11449-350-00

RIDGWAY DAM SPILLWAY AND OUTLET WORKS

(*e*) A 1:30.46 hydraulic model is to be used to develop the morning glory spillway and upper outlet works design. Flow from the upper outlet works is released into the spillway tunnel from gates located in the tunnel crown. Approach flow conditions to the spillway crest, vortex suppression, pressures on upper tunnel and spillway flow surfaces, tunnel defelctor, air demand, tunnel and stilling basin flow conditions, the passage of upper outlet works releases through the tunnel, and the influence of spillway stilling basin and lower outlet works stilling basin on each other will be studied.
(*f*) Active, model under construction.

321-11450-320-00

FLOW CHARACTERISTICS OF CANAL RADIAL CHECK GATES

(*d*) Experimental; applied research.
(*e*) Detailed studies are being made on a 1:6 scale radial gate model to obtain a better definition of flow characteristics such as the coefficient of discharge. There is a need to develop criteria and methods for improving the accuracy of flow measurement through canal check radial gates. These criteria can then be applied to the manual and/or automtic flow regulation of canal systems including mathematical simulation models. The investigation includes the influence of the gate lip with or without gate seals and the variation of the radius to pinion height ratio.
(*g*) The laboratory study will be verified with field data. The results of the study will develop algorithms for the coefficient of discharge for use by canal operators and for mathematical models. Later, the program will be expanded to include the study of hydraulic transient wave siphons.

321-11451-840-00

DRAIN ENVELOPES–PHASE II

(*d*) Applied research.
(*e*) A 0.8-m wide, 3.7-m long, by 2.4-m deep sand tank was constructed to simulate flow conditions for a full-sized subsurface agricultural drain. A 100-mm-diameter corrugated plastic drain tube is surrounded by a 100-mm-thick gravel envelope and a 1.1-m-radius, simulated soil base material. Measurement will be made of the drain discharge and piezometric heads from 143 piezometers located in the soil and gravel envelope for different water table elevations and drain tubing depths. The data will provide a basis for comparing efficiency of other envelopes.
(*g*) Some initial tests were made and difficulties encountered with varying permeability of the simulated soil base material surrounding the drain. Before extensive testing can be done this problem must be solved.

321-11452-840-00

FILTER BED FOR A SMALL PUMPING PLANT

(*d*) Design.
(*e*) A filter bed, placed in the bottom of a river, may be the intake supply for a pumping plant (0.85 m^3/s). The objective is to prevent fine sediment, larger than 74 microns, from entering and damaging the pumps and sprinkler heads in the irrigation system. Preliminary tests are being made with a 0.2 m^2 filter surface area and 0.3-m depth to obtain design information. Filter medium particle size, discharge and head losses during filtering, and required backflushing discharges are needed by the designer to effectively evaluate design needs.

321-11453-350-00

HYDRAULIC MODEL STUDIES OF AN ENERGY DISSIPATOR FOR SUGAR PINE DAM SPILLWAY

(*d*) Experimental, design.
(*e*) The spillway discharges down a steep chute into a stilling basin located in a narrow canyon. The energy must be dissipated in a confined space and the flow turned about 27° to the left to follow the canyon. Environmental considerations and the limited available space precluded the use of a flip bucket to divert the high energy flow away from the structure.
(*f*) Completed.
(*g*) An energy dissipator was developed that included chute blocks at the toe of the chute to separate the incoming jet; curved directional vanes between curved sidewalls; trapezoidal baffle blocks at strategic locations along the vanes and right wall; and a high vertical sill at the end of the basin. Pressure measurements on the chute blocks, baffle blocks, and curved walls indicated subatmospheric pressures at the maximum discharge only at the upstream end of the left wall near the floor. High impact pressures were noted on the surfaces of the blocks that intercepted the flow. Sloping of the upstream ends of the curved vanes was necessary to deflect debris that might pass down the chute. At maximum discharge there was severe bank erosion in the channel downstream from the energy dissipator.
(*h*) Report in preparation.

321-11454-720-00

LOW-AMBIENT-PRESSURE CHAMBER

(*d*) Experimental, basic and applied research.
(*e*) Cavitation damage is a continuing problem at flow surface irregularities, vertical bends in spillway tunnels, and control gates discharging submerged. Field and laboratory studies have been conducted to investigate means of reducing cavitation damage at these problem areas. For each case, questions regarding the effect of the free water surface on the cavitation have arisen. Model tests which duplicate both gravity and cavitation effects require the use of a reduced pressure test environment. Therefore, a low-ambient-pressure test facility is being constructed for cavitation testing with free surface flows. It can also be used for investigations in which the cavitation occurs far from the water surface.
(*g*) Construction of a low-ambient test facility is almost complete. The working section is 3.7 m long, 3.0 m high, and 1.2 m wide. The maximum flow rate is 0.3 m^3/s. The maximum recirculating pump head which can be developed is 24 meters. The pressure in the chamber can be reduced to 15 kPa absolute.

321-11455-350-00

TRUTH OR CONSEQUENCES BAFFLED APRON SPILLWAY

(*b*) Soil Conservation Service, Albuquerque, New Mexico.
(*d*) Experimental; applied research.
(*e*) A 1:30 model was built of the 6.10-m-wide emerging spillway for the 27.4-m-high dam. The height of the blocks was sized for two-thirds of the maximum discharge of 710 m^3/s. The chute and entrance was sized for the maximum discharge. This design procedure worked well for the complete range of discharges. A discharge rating was developed for the ungated flow and the scour downstream from the model was determined. The entrance was modified by inserting a row of blocks between the entrance and the second row of blocks to limit high velocities on the chute.
(*f*) Completed.

(*h*) **Truth or Consequences Baffled Apron Spillway,** R. L. George, *Report GR-79-2*, Apr. 1979.

U.S. DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY, WATER RESOURCES DIVISION, 12201 Sunrise Valley Drive, Reston, Va. 22092. George E. Williams, Chief, Planning Section.

322-0371W-300-00

NUMERICAL SIMULATION OF HYDRODYNAMIC PROCESSES IN RIVERS, ESTUARIES, AND EMBAYMENTS

(*c*) R. A. Baltzer.
(*d*) Basic and applied research.
(*e*) Technical solutions to the problem of investigating and managing waste movement and disposal in regulated rivers, estuaries, and embayments require qualitative and quantitative assessment of the interactions between waste constituents undergoing dynamic transport. Mathematical, numerical, computer-simulation models offer one very powerful solution. Because water is both the vehicle by which the waste constituents are transported and the media in which the constituent interactions occur, the temporal and spatial variations of the flow appreciably govern the interactions both qualitatively and quantitatively. Design of the desired simulation models depends in large measure upon accurate mathematical/numerical representation of the hydrodynamics of the transient flow process.
(*g*) Finite difference modeling: A new one-dimensional, implicit-solution, flow-simulation model was introduced and operationally tested using data from several field locations. This model offers advantages and provides features not found in other currently available models. For example, the model can be very efficiently employed to simulate transient flows in a complex network of interconnected waterways. as well as in a single reach of channel. Among other features, it provides variable weighting of the spatial derivatives in space and time; a functional representation of the energy dissipation factor, *N*; an accomodation for directional, wind-drag effects; direct access to the time-dependent boundary-condition, input/output data files (DAD10); and a wide range of graphical output capabilities. Its most distinctive and perhaps unique feature is the use of a transformation process by which the size of the coefficient matrices is very substantially reduced, thus affording significant savings in computational time and computational storage requirements. The two-dimensional, Port Royal sound, flow/transport simulation model was fully implemented and a very successful initial simulation completed. Improvements in the numerical integration scheme used in the model eliminated previously encountered numerical instability and permitted a substantial reduction in computational time. The feasibility of creating a two-dimensional flow/transport simulation model of the MTF floodway facility was successfully demonstrated. Two useable models of the floodway at different scales are now under development. Finite element modeling: Previous work on the development of a one-dimensional flow model demonstrated clearly the futility of this effort vis-a-vis the existing finite-difference models. All one-dimensional efforts along this course were halted. However, development (by D. Lynch) of a two-dimensional modeling method utilizing an explicit, finite-element technique appears to offer advantages not found using the implicit scheme generally being pursued by most other researchers. Simulation modeling system: The time-series, data-processing, storage-and-retrieval system for use with one-, two-, and three-dimensional models was made operational and is being used by several field offices. The system was expanded to handle the various types of unformatted data–2 byte, 4 byte, 8 byte, and paired data–commonly encountered in modeling. The capability to handle either English or Metric data at several different recording intervals was added. The semi-automated system for generating the initial condition data needed with two- and three-dimensional models was further developed and tested during implementation of the Port Royal Sound model.

322-0372W-090-00

HYDRODYNAMIC STUDY ON THE TRANSPORT (CONVECTIVE DIFFUSION) OF THERMAL, PHYSICAL, AND CHEMICAL CONSTITUENTS IN TURBULENT SURFACE WATER

(*c*) N. Yotsukura.
(*d*) Basic and applied research.
(*e*) Understanding and modeling of turbulent transport (convective diffusion) is the foundation for quantitative description and prediction of distribution of thermal, physical, and chemical constituents in streams, lakes, and estuaries. Need for the constituent model is rapidly increasing because of nationally felt pressure for optimum allocation of surface water resources as well as for controlling water pollution. Specially urgent is the development of thermal models bacause of potential pollution expected from a large-scale nuclear power generation.
(*g*) Summarized the transverse mixing data from various sources and analyzed them by the nondimensionalized Yotsukura-Sayre streamtube mixing equation with good results. The transverse mixing coefficient has a well-defined narrow range of variation even for large rivers such as the Amazon and the Mackenzie. The revised Yotsukura-Cobb formula was completed for estimating mixing distance in rivers and tributaries. Completed the mathematical description of thermal boundary conditions in an unsteady sediment-laden flow with moving boundaries.
(*h*) **Thermal Loading of Natural Streams,** A. P. Jackman, N. Yotsukura, *U.S. Geol. Survey Prof. Paper 991*, 39 p., 1977.
Derivation of Solute-Transport Equations for a Turbulent Natural-Channel Flow, N. Yotsukura, *U.S. Geol. Survey, J. Research* **5**, 3, pp. 277-284, 1977.

322-0373W-220-00

SEDIMENT MOVEMENT AND HILLSLOPE MORPHOLOGY

(*c*) G. P. Williams.
(*d*) Basic and applied research.
(*e*) The bankfull discharge of a stream marks the condition of incipient flooding. Engineers, geomorphologists and others need to be able to predict bankfull discharge at a site, but at present there is no reliable way to do this. The problem, therefore, is to find a dependable way to determine bankfull discharge.
(*g*) Undertook and completed special environmental study on Platte River channel changes.

322-0458W-300-00

CHANNEL MORPHOLOGY IN RELATION TO BEDLOAD AND HILLSLOPE PROCESS

(*c*) L. B. Leopold.
(*d*) Basic and applied research.
(*e*) Little is known about the amount or source of bedload. Bedload may be an important part of the total sediment load moved by streams.
(*g*) Excellent data during flood flow May-June 1976. New data on distribution of velocity with depth in relation to sediment motion. New data on slope of water surface.

322-0461W-220-00

BEDLOAD TRANSPORT RESEARCH

(*c*) W. W. Emmett.
(*e*) Of all processes operating in river channels, and especially of those of practical concern to engineers and others interested in river channel behavior, perhaps the least knowledge is available regarding the the hydraulic and mechanics of bedload transport. Before continuing advances in river channel behavior can be made, some understanding of the behavior of bedload sediment must be made.

(*g*) Field calibration of the sediment-trapping characteristics of the Helley-Smith bedload sampler have been completed. Principal data collection at the conveyor-belt bedload-trap facility have been completed. Analysis of these data are ongoing and draft reports underway. Preliminary field studies undertaken to facilitate transfer of information from site-specific field areas to areal application with emphasis to energy-resource areas and with application to watershed and channel flow/sediment modeling concepts.

(*h*) **1976 Bedload Measurememts, East Fork River, Wyoming,** L. B. Leopold, W. W. Emmet, *Proc. Nat. Acad. of Sciences* **74,** 7, pp. 2644-2648, 1977.

A Comparison of Observed Sediment-Transport Rates With Rates Computed Using Existing Formulas: In Geomorphology in Arid Regions (D. O. Doehring, ed.), *Proc. 8th Ann. Geomorphology Symp.*, State Univ. of N.Y., Binghamton, N.Y., pp. 187-188, Sept. 23-24, 1977.

322-0462W-220-00

RATES AND PROCESSES OF EROSION AND SEDIMENTATION IN NATURAL AND DISTURBED FORESTED DRAINAGE BASINS IN THE DOUGLAS FIR REGION OF THE PACIFIC COAST

(*b*) Conducted for Department of Interior, Bureau of Indian Affairs and National Park Service.

(*c*) R. J. Janda.

(*e*) Most of the timber harvested annually from the Douglas-Fir region is taken from virgin forests by clearcutting. Logging and associated road construction significantly increase stream sediment loads, and considerable controversy exists concerning the magnitude and persistence of the impact of present silvicultural practices. Crucial management and legislative decisions concerning forest practices are being made in an atmosphere of considerable public pressure and controversy. Better understanding of the geomorphic processes operating in this region will provide a more rational basis for pending decisions, and permit objective assessment of the effectiveness of practices proposed to mitigate sedimentation impacts.

(*g*) Analysis of land surface changes over a three year period at 99-pin clusters of erosion-deposition pins indicates that deposition is as prevalent as erosion on both natural hillslopes and hillslopes that have been severely disrupted by recent timber harvest and suggests that in forested terrain small scale surficial erosion processes, like rill erosion and sheetwash, are ineffective in providing sediment to through-flowing streams. The effectiveness of these processes is limited by the storage and buttressing provided by roots, standing trees, and stumps, as well as natural and logging-induced coarse woody debris on the forest floor. Water and suspended-sediment discharge have since 1973 been periodically determined at 6 sites along Redwood Creek and at 26 sites along tributaries showing a wide range of basin characteristics. Intensive study including synoptic observations throughout nine storm events and generation of a synthesized record for the WY1975 and WY1976 storm seasons, suggests that some recently harvested basins yield more than 17 times as much sediment as comparable uncut basins; similarly some basins harvested more than a decade ago still yield about two times as much sediment as comparable uncut basins. Linear regressions were developed to describe suspended-sediment transport relations and an analysis of covariance was used to compare individual regressions. Recently harvested tributaries operate at statistically significant higher levels than unharvested basins. Tributary regressions have statistically significant steeper slopes than mainstem regressions, and thereby help explain the tributary scour-mainstem aggradation observed on aerial photographs and at monumented cross sections following major floods. Under the drought conditions that prevailed during FY1977, relatively little change in land surface configuration was detected at 10 monumented landslides and 140 monumented channel cross sections except at the streamside toes of particularly active slides and along the leading edge of the apparent wave of aggradation along Redwood Creek. The direction and downstream pattern of channel changes were erratic, with scour being only slightly more prevalent than aggradation. Compilation of data concerning amounts of storm precipitation, antecendent moisture conditions including snow accumulations at higher altitudes, and observed stages on Northwestern California Rivers indicate that under similar basin conditions the major storms of 1861 and 1890 probably would have produced flood peaks and volumes quite comparable to or even larger than those associated with the major floods that occured in 1953, 1955, 1965, 1972, and 1975. However, the more recent floods appear to have triggered far more streamside landslides and far more extensive channel aggradation than the late 19th century floods. Probably, the capacity of the basin to resist flood-induced erosion was reduced by recent changes in land use.

(*h*) **Oral Statement and Written Responses to Questions by Dr. R. J. Janda: Hearing Concerning Forest Management and Redwood National Park Before a Subcommittee of the Committee on Government Operations, U.S. House of Representatives, Part 2,** Feb. 9, 1977, R. J. Janda, pp. 53-57, 69-72, 1977.

Preliminary Photo-Interpretative Map of Vegetation and Ground Surface Conditions in the Redwood Creek Drainage Basin, Humboldt County, Calif., D. R. Harden, *U.S. Geol. Survey Open-File Rept.*, 1 p., 1977.

Statement Prepared Consistent with Assistant Secretary of the Interior Robert L. Herbst's October 5, 1977 Testimony at a Hearing of the Senate Subcommittee on Parks and Recreation Concerning Senate Bill 1976, A Bill to Amend the Act of October 12, 1968, Establishing Redwood National Park in California, R. J. Janda, 1977.

322-10693-860-00

OPERATIONAL MODELS OF SURFACE-WATER SYSTEMS

(*c*) M. E. Jennings.

(*d*) Basic and applied research.

(*e*) The lack of operational models of surface-water systems that can be used in water-resources investigations.

(*g*) Digital computer programs and a data management scheme forcompilation and analysis of urban stormwater flow and quality data from Miami, Florida, were developed. Urban stormwater field investigations were also pursued in Houston, Texas and Madison, Wisconsin. A streamflow-aquifer interaction model and an analysis of flow and sediment transport in the Atchafalaya river, Louisiana were completed. Thermal and dissolved oxygen modeling studies in the Chattahoochee river, Georgia were virtually completed. Documentation of status of surface water modeling in USGS was also completed. Approximately 30 percent of staff time was involved in field consultation and training.

(*h*) **Streamflow Routing with Losses to Bank Storage or Wells,** L. F. Land, *NTIS Rept. PB271-535*, 1977.

Downstream-Upstream Reservoir Routing, M. E. Jennings, *NTIS Rept. (not presently numbered)*, 1977.

Urban Stormwater Investigations in Progress by the U.S. Geological Survey, H. H. Barnes, Jr., M. E. Jennings, in *Proc. Workshop on 208 Water Quality Surveys, Non-Point Source Data Acquisition and Interpretation*, City of Chicago, 1977.

Simulation Studies of Flow and Sediment Transport Using a Mathematical Model, Atchafalaya River Basin, Louisiana, M. E. Jennings, L. F. Land, *U.S. Geol. Survey Water Resources Inv. No. 77-14*, 55 p., 1977.

Discussion of Water Yield Model Using SCS Curve Numbers, M. Jennings, *ASCE* **103,** 10, pp. 1243-44, 1977.

322-10694-300-00

CHANGES IN VALLEY MORPHOLOGY, COON CREEK, WISCONSIN

(*c*) S. W. Trimble.

(*d*) Basic and applied research.

(e) Studies of stream and valley morphology, including the collection of detailed hydrologic and sediment data, were made during the period 1934–40 as part of investigations by the U.S. Department of Agriculture related to soil conservation. The morphology has changed considerably since 1940, evidently as a result of changes in land use that altered the hydrologic regime.
(g) Resurveyed 20 ranges (transverse profiles) in Coon Creek Basin, Wisconsin, as an aid in establishing rates of sediment accumulation. Also excavated several sediment-dating markers (buried roads, building foundations, and bridge piers). Resurveyed sediment accumulation in 5 reservoirs in the Coon Creek Basin, and in Lake Marinuka in the nearby Beaver Creek watershed.

322-10695-860-00

MATHEMATICAL SIMULATION OF HYDROGEOLOGIC SYSTEMS

(c) R. L. Cooley.
(d) Basic and applied research.
(e) Satisfactory formulations and solutions of equations approximately describing (1) movement of fluids and components contained in fluids through consolidated and unconsolidated rocks, and (2) interactions of the fluids and rocks accompanying fluid movement, are needed for proper understanding and management of groundwater resources. Such formulations and solutions of equations that apply for general field situations where the flow system is complex and hydrologic data are inexact are not, in general, available.
(g) A study was completed of nonlinear regression as applied to estimate the hydrogeologic parameters (transmissivity of hydraulic conductivity), recharge, discharge, and boundary fluxes for steady-state groundwater flow models of two field areas. Statistical techniques were used to estimate the degree of nonlinearity of the models, goodness of fit of the models to the field data, and the reliability of predictions to be made with the models. A new field application of the nonlinear regression procedures was initiated and is nearly completed. This is a cross-sectional problem where the principal components of the permeability tensors for several layers are to be estimated. Two other methods of parameter estimation were to have been applied by colleagues, but this aspect of the study is as yet incomplete. Prior information in the form of measured values of the parameters and estimates of their variances have been incorporated into the nonlinear regression model and testing on field examples is underway. The statistical procedures for estimating reliability and significance of the model are being revised to incorporate the new methods. A saturated-unsaturated flow model written several years ago is being revised extensively to generalize the areas of possible application and to incorporate more refined numerical solution procedures than used previously.
(h) **A Method for Estimating Parameters and Assessing Reliability for Models of Steady-State Groundwater Flow I. Theory and Numerical Properties,** *Water Resources Res.* **13,** 2, pp. 318-324, 1977.

322-10696-400-00

HYDRODYNAMIC AND MATHEMATICAL MODELING OF CIRCULATION AND TRANSPORT PHENOMENA IN A TIDAL ESTUARY

(c) R. T. Cheng.
(d) Basic and applied research.
(e) The ecosystem of a tide-affected estuary consists of an extremely complicated balance of natural processes. Some of the basic characteristics of such a system, for example the San Francisco Bay, are not well understood. Comprehensive description of the hydrodynamics and the related transport processes is still lacking. Better understanding of the effects of interactions among natural processes and human activities on this system requires advances in basic science and in its application to applied problems. Circulation in a tidal estuary is in response to tides, inflow of fresh water, wind, and gravity and density stratification. Topography of the estuary basin, air-water interaction, turbulent mixing, viscous resistance at the bottom, and rotational effects of the earth, together with the above-mentioned driving forces, constitute a very complicated balance that conserves mass, momentum and energy in the system.
(g) A current meter comparison test which consisted of seven current meters, one tide gauge, and one wind anemometer has been conducted in South San Francisco Bay. Through these field experiments, we have established better working experience and working knowledge of these types of instruments in an estuarine environment. A finite element estuarine hydrodynamic model is developed. Improvements are made specifically with regards to the treatment of lateral boundary conditions. Numerical experiments indicate that the model preserves various conservative properties accurately. Efforts are made in understanding the plankton population dynamics in an estuary. New productivity models are developed to assist analyzing the plankton data collected from San Francisco Bay in the last few years.
(h) **Transient Three-Dimensional Circulation of Lakes,** R. T. Cheng, *Proc. ASCE* **103,** EMI, pp. 17-34, 1977.
Survey of Numerical Models for Wind-Driven Lake Circulation, ASCE 1977 Fall Convention, R. T. Cheng, *Preprint Paper No. 3058*, 30 p., 1977.
Laboratory Evaluation of Four Types of Current Meters, R. T. Cheng, V. R. Schneider, *Abstract, AGU, EOS* **58,** 11, 1 p., 1977.
Field and Modeling Studies of the San francisco Bay Estuarine System, Abstract, T. J. Conomos, D. H. Peterson, R. T. Cheng, to be presented at *Coastal Zone '78*, 1 p., 1978.
An Improved Model to Describe the Effects of Temperature and Irradiance on Algal Growth, J. E. Cloern, Abstract presented, *EPA Symp. on Rate Constants, Coefficients, and Kinetics Formulations in Surface Water Modeling*, Concord, Calif., Feb. 23-25, 1977.
Phytoplankton of the San Francisco Bay Estuary: The State of Our Current Understanding, J. E. Cloern, abstract presented at *Pacific Section Meeting, Am. Soc. of Limno. and Oceano.*, San Francisco, Calif., June 12-16, 1977.
Computational Schemes for Heat Transfer in Temperate Lakes, R. A. Walters, G. F. Carey, D. F. Winter, *Proc. Applications of Computer Methods in Engineering*, pp. 1135-1144.

322-10697-300-00

INFLUENCE OF SEDIMENT AND OTHER VARIABLES ON ACTIVE-CHANNEL GEOMETRY

(c) W. R. Osterkamp.
(d) Basic and applied research.
(e) Recent studies have been made to estimate flow characteristics from channel-geometry data. Even for regional studies, however, large standard errors in discharge-width regressions commonly occur. Current work indicates the discharge-width relation is influenced strongly by sediment and other variables, but present data are inadequate to refine existing regression equations. Information on the effect of particle size on channel shape, which can change in response to land use and hydraulic structures, is desirable for practical purposes. Knowledge of how sediment influences channel shape and stability can permit anticipation and correction of undesirable effects of man's activities.
(g) Field work has been completed and laboratory analyses are nearly complete. Preliminary results demonstrate the effect that sediment exerts on the geometry of alluvial stream channels. The effect of sediment on gradient-discharge relations has also been demonstrated by analysis of data collected for this project.
(h) **Variation of Alluvial-Channel Width With Discharge and Character of Sediment,** W. R. Osterkamp. Abstracts, *10th Intl. Congr. Sedimentology*, Jerusalem, Israel, pp. 491-492, 1978.

Gradient, Discharge, and Particle-Size Relations of Alluvial Channels in Kansas, with Observations on Braiding, W. R. Osterkamp, *Amer. J. Science*, 20 p., 1978.

322-10698-880-00

SEDIMENT YIELD OF STREAMS DRAINING THE PICEANCE BASIN, NORTHWESTERN COLORADO

(*b*) Department of Interior, Bureau of Land Management.
(*c*) V. C. Norman.
(*d*) Basic and applied research.
(*e*) Mining and associated activities have been shown to have a dramatic impact on the sediment yield of streams draining mined areas. In other areas, mining has been shown to increase sediment yield, alter channel geometry and channel morphology, and reduce the conveyance of streams. Prototype oil-shale development in the Piceance Basin will involve the mining, processing, and disposal of over 150,000 tons of oil shale per day. Handling and disposal of such large quantities of spent shale may greatly increase the sediment load in streams.
(*g*) Sediment records have been collected at the sites in the Piceance Basin for two full water years. Sediment yields from many of the basins are influenced by manmade structures such as irrigation diversions and stock ponds. Thus far, the highest measured sediment yields are a factor of about 10 less than the sediment yields predicted by the Pacific Southwest Interagency Committee method.

322-10699-300-00

SEDIMENT MOVEMENT AND CHANNEL CHANGES IN RIVERS

(*c*) R. H. Meade.
(*d*) Basic and applied research.
(*e*) Sediment moves through river systems in response to specific events and changing conditions in drainage basins. These events and conditions are both natural (floods, climate changes) and artificially-induced (accelerated erosion. reservoirs, diversions, channelizations). The response often takes place over periods measurable in decades or longer. The morphology of the river channels changes as sediment moves through the system.
(*g*) Daily sediment loads measured on Amazon River ranged from near 10^6 tonnes per day at Iquitos. Peru, to 3×10^6 tonnes per day at Obidos, Brazil. Effects of reservoirs on downstream sediment loads in Bighorn River are mixed, one reservoir definitely reduced loads downstream, another shows no discernible effect on sediment loads 200 km downstream after 12 years.
(*h*) **Particle Size of Sediments Collected From the Bed of the Amazon River and Its Tributaries, June and July 1976,** C. F. Nordin, R. H. Meade, H. A. Mahoney, B. M. Delaney, *U.S. Geol. Survey Open-File Rept. 77-400*, 22 p., 1977.

322-10700-820-00

DIGITAL MODELING OF GROUNDWATER FLOW

(*c*) S. P. Larson.
(*d*) Basic and applied research.
(*e*) Prediction of the movement of contaminants in a hydrogeologic environment requires knowledge of the velocity distribution of the transporting fluid. Many techniques have been established and implemented for solving groundwater flow problems and corresponding velocity distributions in two dimensions. Solutions to three-dimensional problems of practical interest have been infrequent because of problem size and computational work required. The determination of fluid velocity distributions in three dimensions would provide the necessary first step toward investigation of the movement of contaminants in three-dimensional groundwater problems.
(*g*) Computer code was developed that applies the method of slice-successive overrelaxation to the solution of three-dimensional groundwater flow problems. Preliminary results indicate that problems exhibiting a high degree of numerical connection in the vertical plane can be solved more effectively by this method. A computer program was also developed to implement current U.S. Geological Survey techniques of model parameter estimation. The program is designed to be a companion to the two-dimensional finite-difference model program that is used extensively by WRD hydrologists.
(*h*) **Comparison of Iterative Methods of Solving Two-Dimensional Groundwater Flow Equations,** P. C. Trescott, S. P. Larson, *U.S. Geol. Survey Water Resources Research* **13**, 1, pp. 125-136, 1977.
Optimization Techniques Applied to Groundwater Development, S. P. Larson, T. Maddock, S. S. Papadopulos, *Memoirs XIIIth Congress of Intl. Assoc. of Hydrogeologist* **XIII,** Part 1, Birmingham, England, pp. E57-E66, 1977.
Simulation of Wastewater Injection into a Coastal Aquifer System near Kahalui, Maui, Hawaii, S. P. Larson, S. S. Papadopulos, H. H. Cooper, W. L. Burnham, *Proc. ASCE 25th Ann. Hydraulics Div. Specialty Conf. Hydraulics in the Coastal Zone*, Texas A&M University, College Station, Tex., Aug. 10-12, pp. 107-116, 1977.
Solution of Water Table and Anisotropic Flow Problems Using the Strongly Implicit Procedure, S. P. Larson, P. Trescott, *U.S. Geol. Survey Research J.* **5**, 6, pp. 815-821, 1977.
Aquifer Storage of Heated Water: Part II–Numerical Simulation of Field Results, S. S. Papadopulos, S. P. Larson, *Groundwater* **16**, 4, pp. 242-248, 1978.

322-10703-220-00

MEASUREMENT AND PREDICTION OF SEDIMENT TRANSPORT PHENOMENA

(*c*) D. W. Hubbell.
(*d*) Basic and applied research.
(*e*) In alluvial streams, for every different hydrologic condition, the bed configuration, sediment transport, and hydraulic characteristics mutually change to achieve a quasi-equilibrium. The changes affect the ability of the stream to convey given quantities of water, accommodate navigation, transport and dilute solid and solute wastes, support aquatic biota, and perform similar functions. As yet, no positive means exist for predicting definitely the condition various variables, particularly bed configuration, will achieve for a given set of hydrologic conditions. As a result, optimum utilization and management of a waterway usually cannot be assured and, often, modifications designed to enhance the utility of a waterway are ineffective or have adverse effects.
(*a*) Equipment intended to facilitate the collection and handling of bedload samples from the forthcoming sampler calibration program to be conducted at the SAF hydraulic laboratory, Univ. of Minn., was designed and constructed. Computer programs to compile and process data from the calibration experiments were written and partially debugged, and data analysis techniques were partially established. A field experiment with the Helley-Smith sampler showed that the standard 0.2 mm mesh sample bag readily clogged and produced low sampling efficiencies under conditions of a flat bed, high transport rate, and bed material approximately 90 percent finer than 0.4 mm.
(*h*) **Discussion of Applicability of Unit Stream Power Equation,** D. W. Hubbell, *ASCE Proc.* **103,** HY4, pp. 455-457, 1977.

322-11456-300-47

ROUGHNESS COEFFICIENTS IN HEAVILY VEGETATED FLOOD PLAINS

(*b*) Department of Transportation, Federal Highway Administration.
(*c*) G. J. Arcement, Jr.
(*d*) Basic and applied research.
(*e*) There is increasing interest and activity in the areas of flood plain zoning and of HUD type 15 flood-insurance studies. Hydraulic computations of flow for such studies involve roughness coefficients, often in heavily vegetated flood plains, which are quite different from coefficients in low-water channels. The selection of roughness coeffi-

cients for flood plains remains chiefly an art, particularly where Manning's *n* can be as high as 0.20 in dense growths. Specific guidelines are needed to select roughness coefficients for heavily vegetated flood plains so that *n*-value selection will be consistent.

(*g*) Literature research on roughness coefficients in heavily vegetated flood plains was begun.

322-11457-300-60

COMPUTATION AND REGIONALIZATION OF TIME OF CONCENTRATION AND STORAGE COEFFICIENT VALUES FOR IllINOIS STREAMS

(*b*) Illinois Department of Transportation, Division of Water Resources.
(*c*) B. J. Pruch, Jr.
(*d*) Basic and applied research.
(*e*) Hydrographs for Illinois streams are often needed as input to various hydrologic models used to route flood flows, determine reservoir storage needs, check spillway design, and in other studies. Presently T and K values used in preparing the input hydrographs at ungaged sites are estimated by apportioning methods from values developed at nearby gaged sites. This procedure is time-consuming and tedious.
(*g*) The Corp of Engineers' HEC-1 hydrologic computer model was utilized to determine T and K values at 12 sites with drainage areas greater than 10 square miles. The calculations for T and K were done using the HEC-1 model in the Cyber 175 system at the University of Illinois.

322-11458-300-00

RESERVOIR-SYSTEM AND STREAMFLOW MODELING IN THE DELAWARE RIVER BASIN

(*c*) J. O. Shearman.
(*d*) Basic and applied research.
(*e*) Streamflow from approximately 25 percent of the basin is subject to regulation by reservoirs. Effects of current reservoir operation (and possible alternative operation schemes) on the flow regime and water quality are not fully understood. Therefore, water managers responsible for scheduling reservoir releases are sometimes uncertain as to the overall impact of their decisions. Also, the validity of flood-frequency estimates are sometimes questionable.
(*g*) Work plan formulated but not completely documented. Water-quantity data inventory essentially completed. Began setting up data files on the computer.

322-11459-740-00

MODELING PRINCIPLES

(*c*) J. P. Bennett.
(*d*) Basic and applied research.
(*e*) The development of models of hydrologic systems requires the description of individual processes in mathematical terms and the solution of sets of complex equations in differential form. Research is needed on application of mathematical theory to systems modeling.
(*g*) Conducted extensive planning for field data collection efforts to describe sediment movement in the Potomac estuary. Acquired, designed, and constructed field equipment to further this effort. Collected and analyzed field data showing the distribution of near-surface suspended sediment in the Potomac estuary. Collected and analyzed field data describing the vertical distribution of velocity and suspended sediment in the estuary. Began processing cross-section descriptions and conducting computer runs of a one-dimensional branched Potomac estuary model.

322-11460-870-00

HYDROLOGIC INTERPRETATIONS BASED ON HEAT-FLUX ANALYSES AND THE APPLICATION OF REMOTELY SENSED INFORMATION

(*c*) E. J. Pluhowski.
(*d*) Basic and applied research.
(*e*) Aside from thermal loading stemming from powerplant operations, little has been done to assess man's influence on the thermal patterns of natural streams. Near stream environmental changes due to man's activities may adversely impact stream ecology by altering stream temperatures. In addition to stream-temperature problems, evaluation of remote sensing instrumentation as a method of detecting sources of thermal pollution, sedimentation, and erosion in large water bodies as well as current circulation has obvious application to a wide variety of hydrologic problems.
(*g*) Cooling water discharge at the rate of 30 M^3/sec and flowing as a surface jet orthogonal to the shoreline produced a thermal plume in Lake Ontario that extended 1 km offshore and was 2 km in width in Aguust 1978. The thermal plume created by the power plant located 19 miles northeast of Rochester, N.Y., changes shape rapidly in response to wind speed and direction. It is anticipated that the 10 °C rise in temperature above ambient lake levels created by the heated power plant discharge will be detectable by the HCMM satellite.
(*h*) **Impact of Sewerage Systems on Stream Base Flow and Groundwater Recharge on Long Island, New York**, E. J. Pluhowski, G. A. Spinello, *U.S. Geol. Survey J. Research* **6**, 2, 9 p., 1978.

322-11461-820-00

ANALYSIS OF GROUND-WATER SYSTEMS

(*c*) S. S. Papadopulos.
(*d*) Basic and applied research.
(*e*) Management of groundwater resources requires the determination of the effects of various development schemes on groundwater systems. Evaluation of the hydraulic properties of groundwater systems and understanding of the factors affecting their replenishment and quality are prerequisites for this determination. Existing techniques for groundwater system evaluation are often based on assumptions that do not properly represent field conditions. Improvement of these techniques and development of new more rigorous ones are required to meet future increased uses of groundwater systems.
(*g*) The evaluation of alternative sources of additional water supply for Riyadh, Saudi Arabia, undertaken as a special assignment last year, was completed and an administrative report was prepared for the U.S.–Saudi Arabian Joint Commission on Economic Cooperation. Parameter identification techniques were adapted to the evaluation of layered confining beds through use of an analytical model, and the method was applied to data from an aquifer test at the Osceola National Forest, Florida. In cooperation with other projects (1) numerical energy transport models were evaluated by simulating a field experiment of heat storage in an aquifer; (2) nonlinear programming techniques were adapted to the determination of the optimum yield of an unconfined aquifer under a given set of constraints, and (3) numerical and analytical models were combined to predict the effect of wastewater injection in the saline part of a coastal aquifer system.
(*h*) **Alternative Sources for Additional Water Supply for Riyadh, Saudi Arabia**, S. S. Papadopulos, *United States-Saudi Arabian Joint Commission on Economic Cooperation, Administrative Report*, Dept. of Interior Geol. Survey in cooperation with Kingdom of Saudi Arabia, Min. of Agr. and Wat., Wat. Resources Div. Dept., 150 p., 1977.
Optimization Techniques Applied to Groundwater Development, S. P. Larson, T. Maddock, S. S. Papadopulos, *Memoirs XIIIth Congress of the Intl. Assoc. of Hydrogeologists* **XIII**, Part I, pp. E57-E66, Birmingham, England, 24-30 July 1977.
Simulation of Wastewater Injection into a Coastal Aquifer System Near Kahului, Maui, Hawaii, S. P. Larson, S. S. Papadopulos, H. H. Cooper, Jr., *Proc. ASCE 25th Ann. Hydraulic Div. Specialty Conf*, 1977.

322-11462-070-00

INVESTIGATION OF ENERGY TRANSPORT AND ASSOCIATED MASS TRANSPORT IN POROUS MEDIA INVOLVING BOTH SINGLE AND MULTIPHASE FLOW CONDITIONS

(*c*) J. W. Mercer.
(*d*) Basic and applied research.
(*e*) The subsurface is used for a variety of applications that involve energy transport. Some of these are associated with energy development, for example, geothermal energy and heat storage. Others are associated with residuals management including radioactive waste disposal and waste heat injection. Many of these processes are directly related to associated mass transport problems and some involve multiphase flow. Although various studies have considered subsets of the above problems, a comprehensive methodology is needed to examine heat and mass transport in porous media involving both single and multiphase flow conditions.
(*g*) Final results have been obtained from applying the vertical equilibrium model to the Wairakel, New Zealand field. Simulation was performed over the period 1953 to 2000 with the following conclusions: (1) Preexploitation results indicate that the field had a steam cap; (2) by 1963 the steam cap had increased to include some lower parts of the reservoir; and (3) the limiting factor on production depends on the transient mass leakage, most of which comes from the lower confining bed.

322-11463-390-00

ANALYSIS OF MECHANICAL AND THERMAL WATER-ROCK INTERACTIONS IN FRACTURED HYDROGEOLOGIC SYSTEMS

(*c*) C. R. Faust.
(*d*) Basic and applied research.
(*e*) Management of hydrogeologic systems for diverse purposes such as water supply, waste disposal, heat storage, and geothermal energy requires quantitative methods for determining the effects of water-rock interactions on the behavior of the system. Emphasis in quantifying these effects has been directed to porous media. Application of porous media models to fractured hydrogeologic systems is not always reliable. Furthermore, available techniques devised for fractured media are, in general, impractical and have not been sufficiently field-tested. There is a need to evaluate the available techniques and to devise more reliable and practical methods for analyzing fractured hydrogeologic systems.
(*g*) Completed development and application of modeling techniques for hydrothermal systems. Reviewed literature on groundwater flow in fractured aquifers. Began field study at W. Thornton, N.H. to provide basis for testing various quantitative methods designed for fractured aquifers. Developed computer programs for available analytical solutions for double-porosity aquifers. Developed computer program for finite-element model of double-porosity media. Note, double-porosity is a concept used to describe certain types of fractured aquifers. Started preliminary evaluation of fluid flow and heat transport in high-level radioactive waste repositories.
(*h*) **Geothermal Reservoir Simulation I: Mathematical Models for Liquid- and Vapor Hydrothermal Systems,** C. R. Faust, J. W. Mercer, *Water Resources Research*, 9 p., 1978.
Geothermal Reservoir Simulation II: Numerical Solution Techniques for Liquid- and Vapor-Dominated Hydrothermal Systems, C. R. Faust, J. W. Mercer, *Water Resources Research*, 11 p., 1978.

322-11464-300-60

COMPARISON OF METHODS USED TO COMPUTE FLOOD BACKWATER THROUGH A BRIDGE

(*b*) Wisconsin Department of Natural Resources.
(*c*) D. A. Stedfast.
(*d*) Basic and applied research.
(*e*) Many flood profiles are being determined on Wisconsin streams as a result of HUD flood-insurance studies and water-resource and flood-plain-use planning efforts by the Wisconsin Department of Natural Resources (DNR). These studies are being conducted by many different Federal, state, and local agencies and private consultants using different computer programs and methods. Because so many different methods are in use, information is needed to show how computed results compare.
(*g*) Field surveys for three cross sections and photographs of the study area were obtained. Water surface profiles were computed by various methods and compared to observe profiles.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, AMES RESEARCH CENTER, Moffett Field, Calif. 94035. Mr. C. A. Syvertson, Director.

323-10704-810-00

REMOTE SENSING FOR SNOW AND ICE MAPPING, AND IN-SITU SOIL MOISTURE

(*b*) Cooperative with U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; U.S. Geologic Survey; State of California Snow Surveys Branch; and University of California.
(*c*) Dr. William I. Linlor, Airborne Missions and Applications Division, MS 242-4.
(*d*) Experimental, theoretical, and field investigation; basic and applied research.
(*e*) Important factors in forecasting water runoff rate from snowpacks include the wetness state of the snow and the melting speed (i.e., net heat input rate to the snow). Percolation of meltwater through the snow as well as rainfall affect the wetness state. No automated instrumentation is presently available for measuring snowpack wetness. The present work is investigating methods for wetness determination, using microwave attenuation and phase shifts between a source and receivers. Natural snowpacks at the Central Sierra Snow Laboratory (Donner Summit) are employed. Radar backscatter measurements are also in progress to determine the electromagnetic characteristics of snowpacks, including the effects of layering, dielectric constant, and wetness. The information is to be applied in surface systems to provide assessment of watershed resources on a time-progressive basis, operated automatically, with data transmission via microwave links, or satellites. The microwave techniques are also intended for use in airborne and satellite-based systems.
(*g*) The effect of water on the dielectric constant and attenuation of snow has been measured in the frequency range of 4.0 to 12.0 GHz. The snow condition ranged from dry to completely saturated snow. A microwave system based on a network analyzer was employed to obtain the attenuation and phase shift for snow samples.
(*h*) **Coherent Microwave Backscatter of Natural Snowpacks,** W. I. Linlor, D. J. Angelakos, F. D. Clapp, J. L. Smith, *Report UCB/ERL M77/75*, Electronics Research Laboratory, Univ. of Calif., Berkeley, 15 Nov. 1977.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, LANGLEY RESEARCH CENTER, Langley Station, Hampton, Va. 23665. Donald P. Hearth, Director.

324-09395-420-00

WAVE REFRACTION MODELING OF THE BALTIMORE CANYON CONTINENTAL SHELF REGION AND MODEL VERIFICATION WITH REMOTE SENSING DATA

(*c*) Dr. Charles H. Whitlock, Marine Environments Branch, Mail Stop 272.
(*d*) Theoretical and experimental applied research.

(e) A first-order wave refraction model for the mid-Atlantic continental shelf region between 37.5° and 40° N latitudes is being developed, and remote sensing data are being taken in the region to provide data for verifying the model. Ocean waves are monitored from the edge of the continental shelf until they reach the shoreline to evaluate how the waves are modified by continental shelf bathymetry. This particular region was selected because it fits as a subgrid to a planned National Weather Service ocean wave forecasting system and can be used for coastal wave experiment under the planned SEASAT satellite. A major goal of the research effort is cost reduction of computational activities through use of improved computer technology.

(h) **Finite Amplitude Wave Refraction,** C. E. Grosch, W. J. Comery, Institute of Oceanography, Old Dominion University, Norfolk, Va., *Tech. Rept. No. 34 (Final report prepared under NAS1-11707)*, Jan. 1977.
Minimum-Resource Computer Program for Automatic Generation of Ocean Wave Ray or Crest Diagrams in Shoaling Waters, L. R. Poole, S. R. LeCroy, W. D. Morris, *NASA TM-74076*, Dec. 1977.

324-09396-710-00

REMOTE SENSING OF COASTAL WATERS

(b) Joint Langley and Old Dominion University Project.
(c) Dr. Charles H. Whitlock, Marine Environments Branch, Mail Stop 272.
(d) Experimental, field investigation; applied research.
(e) Major effort has been to monitor suspended sediment (as a natural water tracer) and chlorophyll (as an indicator of water quality). Analysis techniques have been developed for measuring pollutants in water. Future efforts will be directed at automatic analysis of remotely sensed data, through the development of spectral signatures of pollutants, for monitoring water quality in the Coastal Zones.
(f) Completed.
(h) **Mapping of Chlorophyll *a* Distributions in Coastal Zones,** Dr. R. W. Johnson, *Photogrammetric Engrg. and Remote Sensing* 44, 5, pp. 617-624, May 1978.
Multispectral Analysis of Ocean Dumped Materials, Dr. R. W. Johnson, *Proc. 11th Intl. Symp. Remote Sensing of Environment*, Ann Arbor, Mich., Apr. 25-29, 1977.
Quantitative Analysis of Aircraft Multispectral-Scanner Data and Mapping of Water-Quality Parameters in the James River in Virginia, R. W. Johnson, G. S. Bahn, *NASA TP-1021*, Dec. 1977.

324-11465-710-00

MARINE SPECTRAL SIGNATURE AND OPTICAL PHYSICS RESEARCH FOR REMOTE SENSING OF COASTAL AND INLAND WATERS

(c) Dr. Charles H. Whitlock, Marine Environments Branch, Mail Stop 272.
(d) Laboratory, theoretical, and field investigations.
(e) Determine both spectral signatures and the causes of the signatures for various marine pollutants and natural constituents in turbid waters. Measurements of inherent reflectance, attenuation coefficient, absorption coefficient, and volume scattering function ($\Theta = 0.375$ to 160°) are being made at wavelengths of 400 nm, 450 nm, 500 nm, 550 nm, 600 nm, 650 nm, 700 nm, and 800 nm. Both remote-sensing penetration depth and apparent remote-sensing penetration depth are also being measured over the same wavelength range. The underwater optical parameters are input to a number of optical models and their output compared with measured reflectance values and penetration depths over the 400–800 nm wavelength range. Tests are being conducted in the Langley Marine Upwelled Spectral Signature Laboratory and from a specially equipped NASA boat.
(g) Results from previous laboratory reflectance tests and field experiments indicate a variety of spectral signatures occur as a result of different marine constituents. In most casaes, remote-sensing signals icrease with increasing concentration with various degrees of nonlinearity. Reasons for nonlinearity and lack of signal response are not established.
(h) **An Estimate of the Influence of Sediment Concentration and Type of Remote-Sensing Penetration Depth for Various Coastal Waters,** C. H. Whitlock, *NASA TM X-73906*, 1976.
Laboratory Measurements of Reflectance Spectra of Dilute Primary-Treated Sewage Sludge, J. W. Usry, W. G. Witte, C. H. Whitlock, E. A. Gurganus, *NASA TP-1038*, 1977.
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Laboratory and Field Measurements of Upwelled Radiance and Reflectance Spectra of Suspended James River Sediments Near Hopewell Virginia, C. H. Whitlock, W. G. Witte, E. A. Gurganus, J. W. Usry, *NASA TP-1292*, 1978.
Penetration Depth at Green Wavelengths in Turbid Waters, C. H. Whitlock, W. G. Witte, J. W. Usry, E. A. Gurganus, *Photogrammetric Engineering and Remote Sensing* **44,** 11, pp. 1405-1410, Nov. 1978.
Laboratory Measurements of Radiance and Reflectance Spectra of a Dilute Biosolid Industrial Waste Product, J. W. Usry, W. G. Witte, C. H. Whitlock, E. A. Gurganus, *NASA TP-1401*, 1979.
Investigation of the Effects of Background Water on Upwelled Reflectance Spectra and Analysis Techniques for Dilute Primary-Treated Sewage Sludge, C. H. Whitlock, J. W. Usry, W. G. Witte, F. H. Farmer, E. A. Gurganus, *NASA TP-1446*, 1979.

324-11466-710-00

REMOTE AIRBORNE FLUOROSENSOR

(c) Remote Airborne Fluorosensor Team, Marine Environments Branch, Mail Stop 272.
(d) Experimental/field investigation and classed as applied research.
(e) Chlorophyll *a* in vivo fluorescence peaks at 685 nm, and the magnitude of this fluorescence is dependent on the excitation wavelength and the color group to which the phytoplankton belongs. No single excitation wavelength can efficiently excite phytoplankton belonging to all four color groups. The major effort of this research is to develop a Lidar system operating at different wavelengths to excite and measure the fluorescence of chlorophyll *a* in phytoplankton. These data are used to determine the concentration and diversity of the phytoplankton population. Laboratory and field experiments have been conducted using the Lidar system.
(g) Laboratory tests have been conducted and reported. A field test was conducted at Narranganset Bay and the results reported. Laboratory and field experiments have shown that the Lidar system can detect fluorescence of chlorophyll *a*.
(h) **Multiwavelength Laser Introduced Fluorescence of Algae *In Vivo:* A New Remote Sensing Technique,** P. E. Mumola, O. Jarrett, Jr., C. A. Brown, Jr. Presented 2nd Joint Conf. Sensing of Environmental Pollutants, Washington, D. C. Dec. 10-12, 1973.
Laboratory Studies of In Vivo Fluorescence of Phytoplankton, C. A. Brown, Jr., Dr. F. H. Farmer, O. Jarrett, Jr., W. Staton. Presented *4th Joint Conf. Sensing of Environmental Pollutants*, New Orleans, La., Nov. 6-11, 1977.

324-11467-710-00

REMOTE SENSING OF OCEAN DUMPED MATERIALS

(b) Joint Langley, NOAA/NOS, EPA, University of Delaware Project.
(c) Craig W. Ohlhorst, Marine Environments Branch, Mail Stop 272.
(d) Experiment field investigation, applied research.
(e) Major effort has been to determine the applicability of remote-sensing systems for location, identification, and

mapping of ocean dumped wastes in order to develop monitoring systems for agencies responsible for pollution control. Future efforts will be directed at using the dumped materials to study surface water movements in the ocean dumped areas. Concurrent laboratory studies have been undertaken to determine what waste characteristics are mainly responsible for the spectral signatures of the waste material and and how changes in these important characteristics affect the spectral signatures.

(*g*) All ocean dumped materials studied in field experiments, to date, created a color change in the water they mixed with which enabled the waste material to be detected by aircraft platforms. Ocean dump monitoring by aircraft remote sensors is thus feasible. Satellite monitoring is less feasible due to the fact that all the wastes studied (except acid wastes from the manufacture of titanium dioxide) disappeared as surface features within 1 to 8 hours after being dumped. Acid waste and sewage sludge have been quantified in terms of iron concentration and total suspended solids, respectively.

(*h*) **A Summary of the Test Procedures and Operational Details of a Delaware River and an Ocean Dumping Pollution Monitoring Experiment Conducted Aug. 28, 1975,** W. D. Hypes, C. H. Ohlhorst, *NASA TM X-74005*, 1977.

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Quantitative Mapping of Particulate Iron in an Ocean Dump Using Remotely Sensed Data, C. W. Ohlhorst, G. S. Bahn. Presented *Amer. Soc. of Photogrammetry*, Washington, D. C., Feb. 26-Mar. 3, 1978.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, LEWIS RESEARCH CENTER, Cleveland, Ohio 44135. Warner L. Stewart, Director of Aeronautics.

325-07040-630-00

COMPENDIUM ON THE DESIGN OF TURBOPUMPS AND RELATED MACHINERY

(*c*) Cavour H. Hauser, MS 5-9, Head, Single Stage Compressor Section, Fluid System Components Division.

(*d*) Exposition of theoretical and applied research.

(*e*) Compile pertinent information on turbopumps developed by NASA, the various contract research and development programs, and in-house research. This information will be correlated, and considered in proper perspective to provide a coherent presentation of the important principles of turbomachinery design. The Compendium will be published as a NASA Special Publication.

(*f*) Editing of the Compendium is nearing completion.

325-11468-630-00

SMALL PUMPS FOR LIQUID OXYGEN AND LIQUID HYDROGEN

(*c*) R. E. Connelly, M.S. 501-7, Project Manager, Lewis Research Center.

(*d*) Design and development.

(*e*) Purpose is to develop technology for small liquid hydrogen and liquid oxygen pumps for rocket engines. These projects are active; three-stage centrifugal pump for liquid hydrogen, driven by a gas turbine, which operates at 95000 RPM and delivers 6 lbs/sec at 4500 psi; single stage centrifugal pump for liquid oxygen driven by a partial emission gas turbine which operates at 70000 RPM and delivers 36 lbs/sec at 4300 psi; and electric motor driven positive displacement pump (vane pump) for either liquid oxygen or liquid hydrogen which operates at 8000 RPM for hydrogen and 3000 RPM for oxygen. Flow rates are 2.67 gpm for oxygen and 7.80 gpm for hydrogen, pressure rise is 200 to 300 psi.

(*f*) The centrifugal pumps are in test and the vane pump is being fabricated.

325-11469-130-00

MARANGONI BUBBLE MOTION IN ZERO GRAVITY

(*c*) Robert L. Thompson, Aerospace Engineer; Professor Kenneth J. DeWitt, University of Toledo.
(*d*) Theoretical, experimental applied research.
(*e*) The Marangoni phenomenon is proposed as the primary mechanism for the movement of a gas bubble in a non-isothermal liquid in a low gravity environment. An axisymmetirc mathematical model consisting of the Navier-Stokes and thermal energy equations together with the appropriate boundary conditions for both media is being developed. Singular perturbation theory is used to solve this boundary-value problem, with the expansion parameter being the Marangoni number. The zeroth first and second order approximations for the velocity, temperature and pressure distributions in the liquid and in the bubble, and the deformation and terminal velocity of the bubble are determined. This study has application to a fundamental understanding of materials processing, fluid storage and transfer operations, and boiling heat transfer in space.
(*f*) Reduced gravity experiments completed. Analysis including inertial, viscous, thermal and surface tension effects continuing.
(*g*) Experimental zero gravity data for a nitrogen bubble subjected to a linear temperature gradient in ethylene glycol, ethanol and silicon oil were obtained. For small Marangoni numbers comparison of the analytical results for a bubble terminal velocity showed good agreement with the experimental measurements. A NASA TM X is being prepared for publication.

325-11470-130-00

ATOMIZATION OF WATER JETS AND SHEETS IN AXIAL AND SWIRLING AIRFLOWS

(*c*) Robert D. Ingebo, MS 60-6, Aerospace Engineer.
(*d*) Experimental and basic research.
(*e*) Axial and swirling airflows were used to break up water jets and sheets into sprays of droplets to determine the overall effects of orifice diameter, weight flow of air, and the use of an air swirler on fineness of atomization as characterized by mean drop size. A scanning radiometer was used to determine the mean drop diameter of each spray. Swirling airflows were produced with an axial combustor, 70° blade angle, air swirler. Water jets were injected axially upstream, axially downstream and cross stream into the airflow. In addition, pressure atomizing fuel nozzles which produced a sheet and ligament type of breakup were investigated. Increasing the weight flow rate of air or the use of an air swirler markedly reduced the spray mean drop size.
(*f*) Experimental tests in atmospheric pressure airstreams are completed. Tests in high pressure and high velocity airstreams are continuing.
(*h*) **NASA TM-79043,** *24th Ann. Intl. Gas Turbine Conf.*, Mar. 11-15, 1979.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WALLOPS FLIGHT CENTER, Wallops Island, Va. 23337. Dr. Robert L. Krieger, Director.

326-10707-460-00

MICROSCALE AIR-SEA INTERACTIONS AS APPLIED TO REMOTE SENSING OF THE OCEAN

(*c*) Dr. Norden E. Huang, Directorate of Applied Science.
(*d*) Experimental and theoretical; basic and applied research: ongoing joint work with Johns Hopkins University for Doctoral thesis.
(*e*) A new wind, wave, and current interaction tank with several unique features has been completed at Wallops Flight Center. The test section dimensions are 18.29 m (60 ft) in length, 0.91 m (3 ft) in width, and 1.22 m (4 ft) in height and filled to a depth of 0.76 m (2.5 ft). Currents are reversible and variable up to 0.51 m/sec and wind speeds of up to 25 m/sec are available. The major measuring device consists of a laser probe for slope measurements utilizing a new concept for its receiving antenna, producing data accurate to 1° of surface slope for slopes up to 48° and a frequency response beyond 100 Hz. This new device is used in conjunction with an improved capacitance height probe and anemometry equipment to produce wind, wave, and current interaction data which is then processed to yield frequency spectra, auto- and cross-correlations, and probability densities. The processing equipment is managed and controlled by an electronic programmable system controller with computing, scaling, and plotting capabilities. Results are applied to the problems of remote sensing of the ocean.
(*g*) An important new parameter has been identified. Termed the significant slope, S, it is defined as $S = (\zeta^2)^p/\lambda_0$, where ζ is the displacement from mean water level, and λ_o is the wavelength of the energy-containing wave, the wave of frequency n_o, where n_o is the frequency of the maximum of the wave height frequency spectrum. The equilibrium range coefficient for wind generated waves has been found theoretically, in closed form, to be a function of S. Laboratory and field data confirm this result. Additionally, the energy dissipation rate, the skewness of the wave height probability distribution, the deepening of the ocean surface mixed layer, a new model for the ocean surface drift current, and other results have been found to be related to S, the significant slope. Preliminary results from GEOS-3 satellite data, laboratory, and field data have all agreed remarkably well with the theoretical solution for skewness as a function of S for wave height distributions. The present results thus indicate that using these latest theoretical expressions and a radar altimeter operating from space, the following products may be routinely produced: frequency spectra of surface waves, surface drift current, mixed layer depth, drag coefficient for wind stress, rate of wave attenuation, oceanic turbulence generation, and the eddy viscosity.
(*h*) **The Dispersion Relation for a Non-Linear Random Gravity Wave Field,** N. E. Huang, C.-C. Tung, *J. Fluid Mech.* **75,** pp. 337-345, 1976.
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A Study of the Wave Height Probability Distribution and Statistics of Wind Generated Waves, N. E. Huang, S. R. Long. Submitted to *J. Fluid Mech.*, 1979.
A Simple Model of Ocean Surface Drift Current, N. E. Huang. Submitted to *J. Fluid Mech.*, 1979.

NAVAL CONSTRUCTION BATTALION CENTER, CIVIL ENGINEERING LABORATORY, DEPARTMENT OF THE NAVY, Port Hueneme, Calif. 93043. H. L. Gill, Head, Ocean Engineering Department.

327-08498-430-22

TRANSPORTABLE BREAKWATERS

(*b*) Naval Facilities Engineering Command.
(*c*) Director, Foundation Engineering Division, Code L42.
(*d*) Experimental, theoretical, and field investigation; applied research, development.
(*e*) A continuing survey of new developments and occasional analyses of particular concepts for breakwaters are undertaken to identify and evaluate concepts having potential application in a "transportable" or "portable" breakwater.
(*g*) An extensive survey of reports and published papers was conducted and reported. Analyses of flexible blankets, tethered floats, and offset surfaces have been made. Laboratory experiments have yielded data on wave generation and wave transmission for an inclined, hinged plate and on wave transmission and moving forces for a sloping float (inclined pontoon) breakwater module. Development has begun on a mathematical model of the dynamics of a sloping float.
(*h*) **The Behavior of an Inclined Pontoon Breakwater in Water Waves,** F. Raichlen, J.-J. Lee, *Civil Engrg. Lab. Rept. on P.O. No. N62583/78 M R522*, 43 pages, May 1978.
Experiments on an Inclined Pontoon Breakwater in Water Waves, F. Raichlen, *Civil Engrg. Lab. Report on P. O. No. N62583/78 M R668*, 65 pages, Nov. 1978. The reports are available at NTIS and the Civil Engrg. Lab.

327-09410-430-22

DYNAMICS OF FLEXIBLE CABLES IN THE OCEAN

(*b*) Naval Facilities Engineering Command.
(*c*) Dallas Meggitt, Ocean Structures Division, Code L44.
(*d*) Theoretical, laboratory, field studies; applied research.
(*e*) Development of the capability to predict and control dynamic responses of cable/buoy arrays in the deep ocean. The research has been divided into large-displacement low-frequency dynamics, and small-amplitude high-frequency dynamics (strumming). Mathematical models have been developed and tested through laboratory experiments. The models are also being validated with field experiments.
(*g*) Predictive models for the frequency, amplitude and increased drag of strumming cables have been developed and limited comparisons to at-sea measurements have been made. A study of strumming-suppression devices has been started to determine the fluid mechanic mechanisms by which these devices work. An extensive series of laboratory and at-sea experiments have provided a large data base for comparison with computer prediction of large-scale dynamic behavior of cable structures.
(*h*) **Vortex-Excited Vibrations of Marine Cables,** O. M. Griffin, J. H. Patterson, R. A. Skop, S. E. Ramberg, D. J. Meggitt, *Proc. ASCE J. Waterway, Port, Coastal and Ocean Division* (submitted for publication, 1979).
Comparisons Between Small-Scale Cable Dynamics Experimental Results and Simulations Using SEADYN and SNAPLG Computer Models, P. A. Palo, *Civil Engineering Laboratory Tech. Memo. M-44-79-5* (Jan. 1979).
A Survey of Recent Investigations into the Nature of Cable Strumming, Its Mechanisms and Suppression, J. E. Kline, J. J. Nelligan, J. S. Diggs, *MAR, Inc. Tech. Rep. 210* (July 1978).

327-09411-220-22

CONTROL OF SEDIMENTATION IN NAVY HARBORS

(*b*) Naval Facilities Engineering Command.
(*c*) R. J. Malloy, Foundation Engineering Division, Code L42.
(*d*) Applied experimental research.
(*e*) Several conceptual alternatives to conventional dredging are being investigated through laboratory and field experiments, to obtain environmentally cleaner and less expensive techniques/equipment to control sedimentation in Navy harbors.
(*g*) A water jet array was 100 percent successful in preventing sedimentation on the 30 m × 30 in array, but elaborate network of PVC pipe on bottom of berth is subject to damage by ships deploying anchors when mooring. A water jet array positioned along the base of a quay wall was 70 percent effective in preventing sedimentation 50 feet out from the wall. Piping is out of way, so damage is unlikely.
(*h*) **The Evaluation of Sediment Management Procedures Phase I,** W. G. Van Dorn, D. L. Inman, R. W. Harris, *Final Report 1974-1975 SIO Reference Series 75-32*, 1975.
The Evaluation of Sediment Management Procedures Phase II, W. G. Van Dorn, D. L. Inman, R. W. Harris, S. S. McElmury, *Final Report 1975-1976 SIO Reference 77-10*, 1977.
The Evaluation of Sediment Management Procedures Phase III, W. G. Van Dorn, D. L. Inman, S. S. McElmury, *Final Report 1976-1977 SIO Reference 78-18*, 1975.

327-10710-870-22

VACUUM WASTEWATER TRANSFER SYSTEMS

(*b*) Naval Facilities Engineering Command.
(*c*) E. P. Skillman, Environmental Protection Division, Code L54.

(*d*) Experimental, theoretical and field investigation; applied research, development.
(*e*) Develop design criteria for wastewater collection/transportation systems employing a single vacuum transport main in the collection of wastewaters from multiple sources (toilets, kitchens, laundry, showers).
(*f*) Completed.
(*g*) The transport efficiency of a vacuum system (i.e., gallons of wastewater transferred per unit of energy input) is a function of air-to-water ratio. The design head for a vacuum transport system must include the total head that results from the cummulative positive sloping portions of the line and pipe line velocity and friction heads. Vortexing has been found to produce about a 40 percent decrease in vacuum wastewater transfer rate.
(*h*) **Characteristics of Vacuum Wastewater Transfer Systems,** E. P. Skillman, *ASME Publication 76-ENAS-43,* July 1976.

327-11471-420-22

WAVE FORCES ON OCEAN STRUCTURES

(*b*) Naval Facilities Engineering Command.
(*c*) Thomas M. Ward, Code L44, Ocean Structures Division.
(*d*) Development of the capability for reliable estimates of wave forces and the effect of waves on ocean structures.
(*e*) Improved analytical techniques will be formulated, experimental data correlated, and comparisons between predicted and measured parameters will be made.
(*f*) Project is being formulated.

327-11472-430-22

SEAWATER HYDRAULIC TOOL SYSTEMS

(*b*) Naval Facilities Engineering Command.
(*c*) Standley A. Black, Research Mechanical Engineer, Civil Engineering Laboratory, NCBC Code L43, Port Hueneme, Calif. 93043.
(*d*) Theoretical, research and development.
(*e*) Develop medium pressure (1500 psi) hydraulic tool systems for underwater diver use which use seawater in place of oil as the working fluid. The present effort is directed towards the development of a balanced vane motor capable of producing approximately 5 H.P. output. In addition an axial ball piston motor is being fabricated for evaluation.
(*g*) A study of the materials lubrication/corrosion/wear, problems of small positive displacement hydraulic motors using seawater as the lubricant and working fluid was completed. The study recommended development of a balanced (double entry) vane motor. An experimental vane motor is presently being designed and fabricated. In addition a copy of an experimental piston motor, designed and fabricated by the National Engineering Laboratory, East Kilbride, Scotland is being purchased for CEL's test and evaluation.

U.S. NAVAL OCEAN RESEARCH AND DEVELOPMENT ACTIVITY, Department of the Navy, NSTL Station, Miss. 39529.

328-10788-420-00

WAVE-CURRENT INTERACTION STUDIES IN A LARGE-SCALE OUTDOOR SIMULATION FACILITY

(*c*) Ming-Yang Su. Address same as above.
(*d*) Basic theoretical and experimental study.
(*e*) Investigate the influence of the steady nonuniform currents, either with or without curvature, on the wave propagation and its power spectra density. The experimental facility is an outdoor flood plain simulation facility with a dimension of 300' wide, 4500' long and 3' deep. The waves with a crest length of 50' are generated mechanically.
(*f*) The wave-maker has been completed and a wave probe fabricated.
(*g*) Completed a series of experiments which gave the first experimental confirmation of the two-dimensional, non-linear wave-wave interactions among surface gravity waves.
(*h*) Papers on **The Measurement of Directional Wave Spectra and Their Transfer Rate,** are in preparation.

NAVAL OCEAN SYSTEMS CENTER, Department of the Navy, San Diego, Calif. 92152.

329-07219-550-22

PROPULSOR DESIGN

(*b*) Naval Sea Systems Command.
(*c*) D. M. Nelson, Naval Ocean Systems Center, Code 6342.
(*d*) Theoretical, experimental, applied research.
(*e*) Develop advanced theoretical methods for the design of underwater propulsors, program them for high speed computers, and apply them to the design of hardware which may be experimentally verified. Work to date has concentrated on the development of a lifting-surface design method for counter-rotating propellers operating on an axisymmetric body.
(*g*) Recently three sets of counterrotating propellers ranging in application from a small lightweight torpedo to a submarine have been designed, fabricated, and tested. The blade geometry of these designs varied from moderately skewed to highly skewed. Towing basin propulsion tests and water tunnel cavitation tests were performed on all the designs to completely document performance. The propellers performed close to design expectations exhibiting high efficiency and excellent cavitation performance.
(*h*) **Development and Application of a Lifting-Surface Design Method for Counterrotating Propellers,** D. M. Nelson, *NUC TP 326,* Nov. 1972.
A Computer Program Package for Designing Wake-Adapted Counterrotating Propellers: A User's Manual, D. M. Nelson, *NUC TP 494,* Dec. 1975.

329-09450-250-20

WATER JET PHOTOGRAPHY

(*b*) Office of Naval Research.
(*c*) Dr. J. W. Hoyt, Naval Ocean Systems Center, Code 6301.
(*d*) Experimental basic research.
(*e*) The effects of shape parameters on the performance of water-jet nozzles discharging in air were investigated using a camera specially adapted for jet photography. The boundary-layer developing on the exit surface of the nozzle is shown to account for the jet appearance revealed by high speed photography. Optimum nozzles seem to have the boundary-layer transition to turbulence inside the nozzle; transition outside the nozzle being accompanied by spray formation and early jet disruption. The effect of polymer additives seems to be earlier transition and a thinner turbulent boundary layer inside the nozzle which improves jet performance. Also, instabilities occurring in high Reynolds number water jets discharging in air have been made visible. These instabilities include the axisymmetric mode accompanying the transition from laminar to turbulent flow at the nozzle exit, spray formation as a culmination of the axisymmetric disturbances, and further downstream, helical disturbances which result in the entire jet assuming a helical form. The final disruption of the jet is due to amplification of the helical waves. It is further shown that the amplification of the helical disturbances is due in part to aerodynamic form drag, since jets discharging into surrounding air moving at the same speed as the jet remain relatively stable, compared with the case when the jet is discharged into stagnant air.
(*g*) See (e).
(*h*) **Turbulence Structure in a Water Jet Discharging in Air,** J. W. Hoyt, J. J. Taylor, *Physics of Fluids* **20,** p. 5253, 1977.
Effect of Nozzle Shape and Polymer Additives on Water Jet Appearance, J. W. Hoyt, J. J. Taylor, accepted for publication *J. Fluids Engineering.*

Waves on Water Jets, J. W. Hoyt, J. J. Taylor, *J. Fluid Mechanics* **83**, p. 119, 1977.
Elliptical Water Jets, J. W. Hoyt, J. J. Taylor, *AIAA Journal* **16**, p. 85, 1978.

329-10771-010-00

BOUNDARY LAYER CONTROL BY SUCTION

(*b*) Naval Ocean Systems Center, Naval Sea Systems Command.
(*c*) Dr. C. E. Bassett, Naval Ocean Systems Center, Code 631.
(*d*) Experimental basic and applied research.
(*e*) Tests are conducted on various 30-inch long, 2-inch diameter, sting-mounted, porous-shelled models in the NOSC water tunnel at Reynolds numbers up to 10×10^6. Porous materials tested are stainless steel, titanium, polyethylene and Kynar. Also tests are conducted on the effect of suspended ocean type particulates and flow parameters on porous material clogging and boundary layer stability. The objective is to obtain basic information on boundary layer suction for underwater vehicles.
(*g*) Laminar flow has been maintained up to 9×10^6 Reynolds number on porous stainless steel models.
(*h*) **Boundary Layer Development for BLCS Ocean Pipe Flow Experiment**, D. M. Ladd, *NOSC TN 146*, May 1977.
Boundary Layer Control by Suction of a Porous Body of Revolution, P. J. Harvey, *NOSC TN 181*, June 1977.
BLCS Porous Materials, J. C. Logan, *NOSC TN 352*, Oct. 1977.
The Effect of Material and Flow Parameters and Suspended Particulates on the Clogging Rate of Porous Materials, R. L. Bedore, *NOSC TN 453*, Mar. 1978.
BLCS Porous Materials, J. C. Logan, *NOSC TN 352*, Oct. 1977.
The Effect of Material and Flow Parameters and Suspended Particulates on the Clogging Rate of Porous Materials, R. L. Bedore, *NOSC TN 453*, Mar. 1978.
BLCS Porous Materials' Tests, J. C. Logan, *NOSC TN 540*, Oct. 1978.
Water Tunnel Tests of Porous Materials for BLCS Applications, P. J. Harvey, D. M. Ladd, *NOSC TN 570*, Oct. 1978.

329-10773-010-22

ROUGHNESS/TRANSITION EXPERIMENTS

(*b*) Naval Sea Systems Command.
(*c*) Dr. M. M. Reischman, Naval Ocean Systems Center, Code 6342.
(*d*) Experimental applied research.
(*e*) The objective is to measure and evaluate the effects of surface roughness and particulate size and concentration on a thermally stabilized boundary layer. Transition measurements have been made on a 9:1 ellipsoid of revolution in the NOSC, low-turbulence water tunnel utilizing a TSI 1090 laser Doppler anemometer. The model is heated using hot water circulation within the model. Analytical efforts include the utilization of the transition analysis program system (TAPS) computer code to both verify the experimental data and evaluate methods of surface roughness simulation.
(*g*) Extensive data has been taken with cold 9:1 ellipsoid with a 120 μm finish. The results agree with the theoretical analysis and TAPS calculations. Also, data taken for the hot ellipsoid with several overheats agree with results of TAPS calculations. Experiments were performed for both hot and cold cases with the addition of a low concentration of 25 μm particles and no significant effects were observed. An infrared radiation test was performed to observe the transient behavior of the heated body with the use of the constant wall temperature and constant heat flux inserts designed for the model. These tests confirmed both the design technique and the validity of the model surface temperature characteristics.

329-10774-050-20

JET CAVITATION

(*b*) Office of Naval Research.
(*c*) Dr. J. W. Hoyt, Naval Ocean Systems Center, Code 6301.
(*d*) Experimental basic research.
(*e*) Using a specially designed camera adapted for photography of water jets, a study was made of the effect of polymer additives on underwater jet cavitation. The drag-reducing additive, polyacrylamide, at a concentration of 25 parts per million, greatly decreased the cavitation inception index (i.e., it was more difficult to cause cavitation), but more interestingly from the flow visualization standpoint, greatly changed the appearance of the cavitation bubbles. Whereas the bubble appearance in pure water resembled ragged groups of small bubbles with the overall impression of sharpness and roughness, the cavitation bubbles in polymer solution are larger, rounded, and of completely different appearance. Similar results were obtained with the drag-reduction polymer, poly(ethylene oxide). By contrast, the non-drag-reducing polymer, CARBOPOL, did not affect either inception or appearance of the cavitation bubbles; both being similar to water.
(*g*) See (e).
(*h*) **A Photographic Study of Inception and Cavitation in Jet Flow**, J. W. Hoyt, J. J. Taylor, to be presented, *Intl. Symp. Cavitation Inception*, ASME Winter Ann. Mtg., N.Y., Dec. 1979.
Vortex Cavitation in Polymer Solutions, J. W. Hoyt, *ASME Cavitation and Polyphase Flow Forum*, p. 17, 1978.

329-11483-130-00

BUBBLE SIZE EXPERIMENTS

(*b*) Naval Ocean Systems Center, IR&IED Program.
(*c*) Dr. M. M. Reischman, Naval Ocean Systems Center, Code 6342.
(*d*) Experimental, basic and applied research.
(*e*) The objective of the research was to conduct lab-scale experimental research on sizes and distribution of bubbles generated by gas flow exiting into water flow as a function of gas flow rate, water flow rate, ejector geometry, and upstream turbulence. The goal of the research is to determine gas ejection configurations and parameters for future naval vehicles that limit bubble sizes to those of minimal acoustic interference.
(*f*) Completed.
(*g*) Experiments were conducted on a flat plate apparatus in the NOSC, low-turbulence, high-speed water tunnel. Data was collected photographically and reduced via subsequent digital image processing and computer analysis. Results indicate that the ratio of gas flow to freestream water velocity is the primary variable affecting the mean bubble diameter. The air ejection hole diameter has minimal effect on the mean diamter but weakly influences the width of the bubble distribution. Boundary layer thickness and hole angle also have no distinct effects. It was also shown that the data reduction method, video digitization, has broad applicability in the extraction of numerical results from flow visualization data.
(*h*) **Numerical Hydromechanics Data From Digital Image Arrays**, N. H. Hughes, M. M. Reischman, J. M. Holzmann, *Proc. SPIE*, **155**, p. 191-98, Aug. 1978.

329-11484-010-00

TRANSITION FLOW NOISE

(*b*) Naval Material Command, NOSC IR&IED.
(*c*) T. S. Mautner, Naval Ocean systems Center, Code 6342.
(*d*) Basic experimental research.
(*e*) The objective is to measure the transducer response produced by the wall pressure fluctuations associated with the turbulent spot phase of boundary layer transition. Experimental results will establish the variation of flow noise as a function of turbulent spot location. Wall pressure fluctuations will be measured by microphones mounted in a flat plate apparatus in the UCSD wind tunnel. The microphones will measure the boundary layer noise at

various locations with respect to the origin of the artificially generated turbulent spots as they travel in an otherwise laminar boundary layer.

(*g*) Preliminary results show that the ensemble mean (i.e., 1000 events) of the turbulent spot pressure field has peak pressures from 8-20 times greater than the laminar boundary layer values. Also, the peak pressures correspond to the passage of the leading and trailing edges of the spot velocity field and the convection velocities of the pressure and velocity (at the wall) field are nearly identical.

U.S. NAVAL RESEARCH LABORATORY, Washington, D. C. 20375. E. E. Henifin, CAPT, USN, Commander.

331-07065-420-22

MICROWAVE SCATTERING FROM WIND WAVES

(*c*) Dr. W. J. Plant, Dr. G. R. Valenzuela, W. C. Keller, Code 8344.

(*d*) Field studies of modulated microwave backscatter from the sea surface are performed. Influences of air flow, surface contaminants, and air-sea temperature differences on the backscatter are examined.

(*h*) **Studies of Backscattered Sea Return, with a CW, Dual-Frequency X-Band Radar,** W. J. Plant, *IEEE Trans. on Ant. & Prop.* **AP-21,** 1, 28 (1977).
Growth and Equilibrium of Short Gravity Waves in a Wind-Wave Tank, W. J. Plant, J. W. Wright, *J. Fluid Mech.* **82,** 4, 767 (1977).
Modulation of Coherent Microwave Backscatter by Shoaling Waves, *J. Geophys. Res.* **83,** C3, 1347 (1978).

331-07067-420-00

SEA SPECTRA ANALYSIS

(*c*) Denzil Stilwell, Jr., Code 7924.

(*d*) Experimental and theoretical investigations of optical techniques for the measurement of statistical descriptors of the ocean surface.

(*e*) This program provides ocean wave information by coherent optical analysis of ocean surface images.

(*g*) Present efforts are exploiting non-photographic methods to obtain near real time spectral analysis capability.

(*h*) **Determination of Ocean Surface Descriptors Using Sea Photo Analysis Techniques,** R. O. Pilon, *NRL Rept. 7574, July 1973.*
Directional Spectra of Surface Waves from Photographs, D. Stilwell, Jr., R. O. Pilon, *J. Geophys. Res.* **79,** 9, pp. 1277-1284, Mar. 1974.

331-08524-250-00

STABILITY OF LAMINAR PIPE FLOWS OF VISCOELASTIC LIQUIDS

(*c*) R. J. Hansen, Code 8444.

(*d*) Theoretical basic research.

(*e*) A spectral method has been developed to study the stability of fully-developed pipe flows of rheologically complex fluids. Chebyshev polynomials have been utilized in the development of the method.

(*f*) Completed.

(*g*) Computations performed using the method have established that liquid viscoelasticity (represented by the convected derivative terms in the Oldroyd constitutive equation) destabilizes a laminar pipe flow. This result is consistent with experimental work on the "early turbulence" phenomenon in pipe flows of viscoelastic liquids.

(*h*) **Numerical Study of the Hydrodynamic Stability of Pipe Flows of Newtonian and Viscoelastic Fluids by a Chebyshev Expansion Function Method,** R. J. Hansen, M. D. Kelleher, *Proc. 1st Intl. Conf. on Numerical Methods in Laminar and Turbulent Flows*, pp. 923-934 (1978).

331-09418-010-22

TURBULENT STRUCTURE OF GEOPHYSICAL BOUNDARY LAYERS

(*b*) Department of the Navy.

(*c*) Mr. Clifford Gordon, Code 8345.

(*d*) Field studies of the benthic boundary layer in an estuary including measurements of Reynolds stress, turbulent kinetic energy and velocity profiles.

(*e*) Establish whether the findings of contemporary wind tunnel and laboratory boundary layer investigations are directly applicable to the large scale turbulent structure of geophysical boundary layers. The most specific interest is in the scaling behavior of the bursting phenomenon.

(*g*) Direct measurements have shown that most of the vertical transport of horizontal momentum in a marine boundary layer occurs intermittently; 90 percent of the transport takes place in about 30 percent of the time.

(*h*) **Sediment Entrainment and Suspension in a Turbulent Tidal Flow,** C. M. Gordon, *Marine Geology* **18,** pp. 57-64, 1975.
Turbulent Structure in a Benthic Boundary Layer, C. M. Gordon, J. Witting, *Bottom Turbulence, Elsevier Oceanographic Series* **19,** pp. 59-81, 1977.

331-09420-250-00

INTERACTION OF A SHEAR FLOW WITH A COMPLIANT BOUNDARY

(*b*) Office of Naval Research.

(*c*) R. J. Hansen.

(*d*) Experimental and theoretical basic research.

(*e*) The effects of surface compliance on boundary layer flows is examined experimentally and theoretically. Of particular interest are alterations in skin friction drag due to surface compliance and deformations in the surface caused by the fluid.

(*g*) An experimental study of the flow over a compliant region of a flat plate has been completed. Three major classes of surface waves generated by the flow are identified in terms of their origin and propagation velocities. The nondimensional onset velocity for two of the three types of waves is identical to that previously observed in rotating disk experiments. The third type of wave, associated with irregularities in the coating topography, has a lower onset velocity. A high-aspect-ratio rectangular channel has been constructed to conduct detailed studies of the effects of various types of flexible surfaces on skin friction drag.

331-10711-030-20

FLOW-INDUCED MOTIONS OF FLEXIBLE CABLES AND CYLINDERS ALIGNED WITH THE MEAN FLOW DIRECTION

(*b*) Office of Naval Research.

(*c*) C. C. Ni and R. J. Hansen, Code 8444, Bldg. 3-4.

(*d*) Basic and applied experimental research.

(*e*) A large, blowdown water channel with a 14.8 m long, 19 cm i.d. transparent test section is used in this work. Flow velocities in the test section of up to 9 m/sec can be realized. A rigid rod of the same diameter as the flexible test specimen is mounted on the axis of the test section for the first twenty hydraulic diameters to produce a fully developed annular flow. The front end of the test specimen is attached to the downstream end of this rod, and the downstream extremity of the test piece may be either free to move or fixed. The lateral, flow-induced motions of the flexible cable or cylinder are monitored optically.

(*g*) Flow-induced lateral motions on the order of one cylinder diameter in amplitude are observed in 1.6 cm diameter flexible cables and cylinders. The motions can be described as a limited band stationary, random process of predominantly low frequency content (under 20 Hz). The measured drag coefficient of a flexible cylinder with a free downstream end is lower thant that predicted by previous theoretical studies of turbulent, annular flows.

(*h*) **An Experimental Study of the Flow-Induced Motions of a Flexible Cylinder in Axial Flow,** C. C. Ni, R. J. Hansen, *J. Fluids Engrg., Trans. ASME* **100,** pp. 389-394 (1978).
Flow-Induced Transverse Motions of a Flexible Cable Aligned with the Flow Direction, *Proc. Oceans '78 4th Ann. Combined Conf. of M.T.S. and I.E.E.E.*, pp. 287-290 (1978).

331-11494-420-00

LANGRANGIAN WIND AND CURRENT VECTORS VERY CLOSE TO A SHORT-FETCH WIND-SWEPT SURFACE

(*c*) Allen H. Schooley, Ocean Sciences Division.
(*g*) Drag or wind stress, used in aeronautics and drag or wind stress, used in oceanography, are essentially equivalent under short fetch conditions where the wind velocity, substantially exceeds the water velocity. Likewise, lift and wave height are related under the same conditions. An average short fetch wind wave of 10 m sec^{-1} shows the properties of increasing drag and lift from the trough to the skewed down-wind peak. Immediately after the peak the drag and lift drop to a low value corresponding to a region of aerodynamic stall. Recovery is rapid and the process is repeated for the next wave. In spite of the similarities, short fetch water waves are not well designed air foils. They are somewhat like flying an airfoil backwards.

331-11495-420-20

WAVE FORCES ON OFFSHORE STRUCTURES

(*b*) Office of Naval Research.
(*c*) Steven E. Ramberg, Owen M. Griffin, Code 8441.
(*d*) Applied experimental and theoretical research.
(*e*) The wave forces on horizontal, vertical and inclined cylinders are studied in the so-called Morison regime where both drag and inertial forces are important. Of particular interest are the sensitivities of the usual prediction methods to procedural variations and to common hydrodynamic assumptions. Consistent methods and in some instances alternate approaches are sought in order to improve the resolution of a typical wave force prediction.
(*g*) A number of sources of uncertainty in wave force prediction have been identified and discussed. Several sources have been attributed to common variations and to common errors in the methods of computing empirical force transfer coefficients, while other sources have been traced to hydrodynamic oversimplifications. The hydrodynamic errors have been shown to stem from an inadequate accounting for the eccentricity of water particle orbits under waves, the orientation of the orbits with respect to the cylinder, and the variation of flow over the length of a cylinder. Consideration of these effects has led to a modified form of the Morison equation for horizontal cylinders and has indicated techniques for improving cylinder force predictions on cylinders mounted vertically in waves. Comparisons with laboratory data and previous results have been performed with favorable results. Implications for inclined cylinders and short-crested seas have been discussed.
(*h*) **Some Errors and Uncertainties in Wave Force Computations,** S. E. Ramberg, J. M. Niedzwecki, *Offshore Technology Conf. Paper 3597* (May 1979).

331-11496-420-20

NUMERICAL SIMULATION OF OCEAN SURFACE WAVES

(*b*) Office of Naval Research.
(*c*) E. Wade Miner, Code 8441.
(*d*) Basic research in numerical fluid mechanics.
(*e*) Research is being conducted to develop techniques for the numerical simulation of progressive free-surface waves. The present computer code, SPLISH, uses a finite-difference method and a triangular mesh to solve the governing partial differential equations which are in a Lagrangian formulation. Computational resources are conserved by limiting the domain to one wave-length and by imposing periodic side boundary conditions. The long range goal of the research is the calculation of wave effects on ocean structures.
(*g*) Good simulations for two-dimensional wave flow (e.g., a constant-depth wave channel) have been achieved. Simulated wave periods and particle trajectories agree well with classical non-linear wave theory. Simulations have also been achieved with good results for wave flow over a half-cylinder mounted on the channel bottom. Data from the simulations for the wave-induced pressure fluctuations over the half-cylinder appear promising.
(*h*) **A Finite-Difference Method for Calculating Free Surface Waves,** E. W. Miner, M. J. Fritts, O. M. Griffin, *Proc. 1st Intl. Conf. Numerical Methods in Laminar and Turbulent Flow*, pp. 597-608, Swansea, U.K., July 17-21, 1978.

DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER, Department of the Navy, Headquarters, Bethesda, Md. 20084. Captain Myron V. Ricketts, USN, Commander; Dr. Alan Powell Technical Director.

ANNAPOLIS LABORATORY, SHIP MATERIALS ENGINEERING DEPARTMENT, Annapolis, Md. 21402.

332-10713-520-22

MATERIALS FOR HIGH PERFORMANCE SHIPS

(*b*) Naval Sea Systems Command.
(*c*) A. Rufolo, Non-Metallics Division and J. J. Kelly, Planning and Analysis Office.
(*d*) Experimental; applied research and development.
(*e*) Development of coatings and overlay materials which can provide corrosion, erosion and antifouling protection; of structural materials which can resist erosion, primarily that produced by cavitation; of fabric reinforced rubber for seals and skirts of surface effect ships (SES) and surface effect vehicles (SEV). Cavitation studies are performed on (1) a rotating disk apparatus, (2) vibratory equipment, and (3) a high speed Venturi nozzle. Dynamic performance studies on fabric reinforced rubber are carried out on a rotating drum impactor. Field trials have included experimental applications on Navy hydrofoils and air-cushion vehicles (ACV).
(*g*) Materials with high resistance to cavitation erosion have been evaluated and catalogued. Skirt/seal operational life, demonstrated to be a critical problem, has been increased through the discriminating selection of the components of fabric-reinforced rubbers. Basic studies continue on the dynamic behavior of skirt/seal materials.

332-11473-690-00

SYNTHETIC TRIARYL PHOSPHATES AS FIRE RESISTANT HYDRAULIC FLUIDS

(*b*) Naval Ship Engineering Center.
(*c*) Mr. C. L. Brown, Lubrication, Friction, and Wear Branch.
(*d*) Applied research and development.
(*e*) Investigations are in progress to determine the suitability of synthetically prepared triaryl phosphate fluids as replacements for Specification MIL-H-19457B triaryl phosphates which are derived from natural products. The MIL-H-19457B fluids are currently used in Navy surface ship hydraulic systems where fire resistant fluids are required. However, the fluid is considered potentially more active physiologically than is desirable. Therefore a less physiologically active replacement fluid is desired. Two types of synthetic fluids are being investigated; the isopropylated triaryl phosphates and the tertiary butylated triaryl phosphates. Physical and chemical measurements and performance evaluations are in progress to determine their suitability.
(*g*) The tertiary butylated triaryl phosphate type is considered more promising than the isopropyl phosphate type fluid because of its superior fire resistance. The adequacy of the lubricating ability of the tertiary butylated fluid is under investigation.

332-11474-690-22

SYNTHETIC HYDROCARBONS FOR NAVY HYDRAULIC SYSTEMS

(*b*) Naval Sea Systems Command.
(*c*) Mr. C. L. Brown and Dr. R. W. McQuaid, Lubrication, Friction, and Wear Branch.
(*d*) Applied research and development.
(*e*) The project is aimed at developing synthetic hydrocarbon base hydraulic fluids as replacements for four petroleum base fluids now in naval applications, MIL-L-17331 (MS 2190-TEP), MIL-L-17672 (MS 2075-TH and MS 2110-TH) and MIL-F-17111. The replacement fluids are required because the petroleum industry is finding it increasingly difficult to maintain constancy of base fluids as required under the current military specifications. Two types of synthetic fluids (poly alpha olefins and dialkyl benzenes) are being evaluated as possible substitute base fluids. Performance improving additives will be incorporated into the fluids to provide finished fluid performance that will be equivalent to the respective current petroleum-base fluids. Bench scale and full-scale performance evaluations will be conducted. The most successful fluid formulations will be subjected to evaluation in Fleet hydraulic systems.
(*g*) New project–no significant results.

332-11475-690-00

VALVE STICKING CHARACTERISTICS OF HYDRAULIC FLUIDS

(*b*) Naval Ship Engineering Center.
(*c*) Mr. C. L. Brown, Lubrication, Friction, and Wear Branch.
(*d*) Applied research and development.
(*e*) The project is aimed at evaluating valve sticking tendencies of Navy petroleum-base hydraulic fluids and providing remedial action. Chemical analyses and physical performance experiments have been conducted to determine the cause of valve sticking which actually occurred in a ship hydraulic system. This included the design and construction of a laboratory rig to measure valve actuation forces using actual system valves.
(*g*) Two components of one manufacturer's fluid have been identified as able to cause valve sticking when used in combination with each other. A method for measuring valve sticking tendencies has been incorporated in military specification MIL-L-17331 for the hydraulic fluid. The valve sticking tendencies of other classes of hydraulic fluids are being explored.

DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER, Department of the Navy, Headquarters, Bethesda, Md. 20084.

CARDEROCK LABORATORY, SHIP PERFORMANCE DEPARTMENT, Bethesda, Md. 20084.

333-09431-550-22

BLADE LOADING OF CONTROLLABLE PITCH PROPELLERS

(*b*) Naval Sea Systems Command.
(*c*) Robert J. Boswell, Propulsor Technology.
(*d*) Experimental; development.
(*e*) A combined experimental and analytical program is underway to develop improved techniques for predicting blade loading of controllable-pitch propellers over a complete range of operating conditions. This is necessary in order to improve the design technology and structural reliability of controllable pitch propellers. The six components of blade loading were measured behind a single screw hull and two twin-screw hulls simulating the following conditions: steady ahead, crash astern (deceleration), crash ahead (acceleration), and ship motions. Dependent upon the conditions simulated, the time average, transient, and unsteady portions of each component of blade loading were determined. Additional experiments under idealized flow conditions were conducted in an attempt to isolate the reasons for discrepancy between theory and experiments as described in paragraph (g).
(*g*) The experimental results behind the model hulls showed that waves and hull pitching substantially increase the unsteady loading, and that unsteady loading during simulated crash ahead and crash astern operation was smaller than the unsteady loading for full power steady ahead operation. Experiments in idealized flows showed that available theories give adequate prediction of unsteady loads in axial wakes but substantially underpredict unsteady loads in tangential wakes.
(*h*) **Experimental Unsteady and Time Average Loads on the Blades of the CP Propeller on a Model of the DD-963 Class Destroyer for Simulated Modes of Operation,** S. D. Jessup, R. J. Boswell, J. J. Nelka, *DTNSRDC Report 77-0110*, Defense Documentation center ADA-048385, Dec. 1977.
Experimental Time Average and Unsteady Loads on the Blades of a CP Propeller Behind a Model of the DD-963 Class Destroyer, R. J. Boswell, S. D. Jessup, J. J. Nelka, *Propellers '78 Symposium, Soc. Naval Architects and Marine Engrs. Publication S-6*, Virginia Beach, Va., pp. 7/1-7/28, 24-25 May 1978.
Experimental Determination of Periodic Propeller Blade Loads in a Towing Tank, R. J. Boswell, S. D. Jessup, *Proc. 18th Amer. Towing Tank Conf.* **I**, U.S. Naval Academy, Annapolis, Md., pp. 263-270, Aug. 1977.

333-09432-550-22

PROPELLER BLADE PRESSURE DISTRIBUTION

(*b*) Naval Sea Systems Command.
(*c*) Robert J. Boswell, Propulsor Technology.
(*d*) Experimental; development.
(*e*) Provide experimental measurements of the pressure distribution on models of controllable pitch (CP) propellers. Measurements have been made at 40 locations on two propellers in uniform flow and in inclined flow over a range of advance coefficients. This information is required in order to evaluate the theoretical methods being developed for predicting the hydrodynamic performance of propellers, and in order to improve the design technology and structural reliability of CP propellers.
(*g*) Preliminary analysis of the results indicates that in inclined flow the unsteady pressure differential between back-to-back points on the opposite surfaces of the blade is larger than predicted by available theories.

333-09437-010-00

STRUCTURE OF BOUNDARY LAYERS AND TURBULENCE WITH APPLICATION TO DRAG REDUCTION, NOISE GENERATION, AND WAKE DETECTION

(*c*) Dr. T. T. Huang, Hydrodynamics Branch.
(*d*) Experimental work, basic research.
(*e*) Measure the structure of hydrodynamic turbulence by hot-film anenometers and Laser Doppler Velocimeter (LDV) in boundary layers, wakes, and jets, with emphasis on data relevant to drag reduction, transition, noise generation, cavitation, wake detection and diffusion.
(*g*) Hot-film measurements and detailed computation of the structure of high Reynolds number turbulence behind a grid in a water tunnel have been completed. Hot-wire measurements of turbulence structure on thick axisymmetric boundary layer. Pressure fluctuation in the regions of flow transition have been measured. Analytical investigation of the influence of viscous effects on a model/full-scale cavitation scaling has been made. Hot-wire measurements of turbulence structure on thick axisymmetric boundary layer have been completed.
(*h*) **Stern Boundary-Layer Flow on Axisymmetric Bodies,** T. T. Huang, et al., *12th Symp. Naval Hydrodynamics*, Washington, D.C., 5-9 June, 1978.
Calculation of Potential Flow/Boundary Layer Interaction on Axisymmetric Bodies, H. T. Wang, T. T. Huang, *Symp.*

Turbulent Boundary Layers, Niagara Falls, N.Y., 18-20 June 1979.

333-09441-550-00

PROPELLER-HULL INTERACTION

(*b*) Naval Sea Systems Command.
(*c*) T. T. Huang, Hydrodynamics Branch.
(*d*) Experimental and theoretical work; applied research.
(*e*) Development of theoretical and computational methods to predict the effect of a propeller on thrust deduction and wake fraction. Experiments to determine propeller-induced boundary-layer velocity perturbations will be made with a laser-Doppler velocimeter.
(*g*) Theoretical and experimental work for axisymmetric bodies has been completed.
(*h*) **Propeller/Stern/Boundary-Layer Interaction on Axisymmetric Bodies: Theory and Experiment,** T. T. Huang, H. T. Wang, N. Santelli, N. C. Groves, *DTNSRDC Rept. 76-0113*, Dec. 1976.
Interaction of Afterbody Boundary Layer and Propeller, T. T. Huang, B. D. Cox, presented *Symp. Hydrodynamics of Ship and Offshore Propulsion Systems*, Høvik, Oslo, Norway, 20-25 Mar. 1977 (sponsored by Det norske Veritas).

333-09442-030-00

FLOW TRANSITION AND TURBULENCE STIMULATION

(*b*) Naval Sea Systems Command..
(*c*) J. H. McCarthy, J. Power, Hydrodynamics Branch.
(*d*) Experimental work primarily; applied research.
(*e*) Determination of the locations of flow transition and laminar separation on axisymmetric models at Reynolds numbers of up to 4 x 10^7. Determination of effective turbulence-stimulation techniques and development of improved methods for predicting prototype drag from model drag measurements.
(*f*) Completed.
(*g*) Experiments on nine bodies have been completed.

333-09444-520-20

NUMERICAL HYDROMECHANICS OF NAVAL VEHICLES

(*b*) Office of Naval Research and Naval Sea Systems Command.
(*c*) Dr. Nils Salvesen, Hydrodynamics Branch.
(*d*) Numerical and theoretical; applied research.
(*e*) Develop direct numerical methods for the prediction of those free-surface performance characteristics of Naval ships and advanced vehicles which cannot be satisfactorily predicted by conventional methods. Attention will be focused on the following problem areas: nonlinear ship wave resistance, large amplitude ship motion, and nonlinear local flow problems.
(*h*) **Added Mass of a Rectangular Cylinder in a Rectangular Canal,** K. J. Bai, *J. Hydronautics* **11,** 2, 1977.
Zero-Frequency Hydrodynamic Coefficients of Vertical Axisymmetric Bodies at a Free Surface, K. J. Bai, *J. Hydronautics* **11,** 2, 1977.
The Added Mass of Two-Dimensional Cylinders Heaving in Water of Finite Depth, K. J. Bai, *J. Fluid Mechanics* **81,** 1977.
A Localized Finite-Element Method for Steady, Three-Dimensional Ship-Wave Problems, *2nd Intl. Conf. Numerical Ship Hydrodynamics*, Univ. of Calif., Berkeley, 1977.
Sway Added-Mass of Cylinders in a Canal Using Dual Extremum Principles, K. J. Bai, *J. Ship Research* **21,** 4, 1977.
A Localized Finite-Element Method for Two-Dimensional Steady Potential Flows with a Free Surface, K. J. Bai, *J. Ship Research* **22,** 4, 1978.
Blockage and Blockage Correction with a Free Surface, K. J. Bai, submitted to *J. Fluid Mechanics*, 1978.
A Note of Blockage Corrections, K. J. Bai, *DTNSRDC Report 78/81*, 1978.
Computations of Three-Dimensional Ship Motion with Forward Speed, M. S. Chang, *2nd Intl. Conf. Numerical Ship Hydrodynamics*, Univ. California, Berkeley, 1977.
Large Amplitude Transient Motion of Two-Dimensional Floating Bodies, R. B. Chapman, submitted to *J. Ship Research*, 1978.
Boundary-Fitted Coordinate Systems for Domains Containing Arbitrary Three-Dimensional Bodies, R. M. Coleman, *DTNSRDC Report 78/085*, 1978.
Finite-Difference Computations Using Boundary-Fitted Coordinate Systems for Free-Surface Potential Flows Generated by Submerged Bodies, H. J. Haussling, R. M. Coleman, *2nd Intl. Conf. Numerical Ship Hydrodynamics*, Univ. California, Berkeley, 1977.
Waves and Wave Resistance for Air-Cushion Vehicles with Time-Dependent Cushion Pressures, H. J. Haussling, R. J. Van Eseltine, *J. Ship Research* **22,** 3, 1978.
Nonlinear Water Waves Generated by an Accelerated Circular Cylinder, H. J. Haussling, R. M. Coleman, *J. Fluid Mechanics*, 1977.
Numerical Solutions of Transient Three-Dimensional Ship-Wave Problems, S. Ohring, J. Telste, *2nd Intl. Conf. Numerical Ship Hydrodynamics*, Univ. California, Berkeley, 1977.
Non-Linear Aspects of Subcritical Shallow-Water Flow Past Two-Dimensional Obstructions, N. Salvesen, C. von Kerczek, *J. Ship Research* **22,** 4, 1978.
Ship Motions in Large Waves, N. Salvesen, *Symp. Applied Mathematics*, dedicated to the late Prof. Dr. R. Timman, Delft University, The Netherlands, 1978.
Nonlinear Free-Surface Effects–The Dependence on Froude Number, C. von Kerczek, N. Salvesen, *2nd Intl. Conf. Numerical Ship Hydrodynamics*, Univ. of California, Berkeley, 1977.

333-10716-030-22

BODIES ON OR NEAR A FREE-SURFACE

(*b*) Naval Sea Systems Command.
(*c*) Dr. Ming-Shung Chang, Hydrodynamics Branch.
(*d*) Numerical and theoretical; applied research.
(*e*) Develop techniques to improve the predictions of ships' characteristics when operating on or near a free surface. Special problems of interest are the wave resistance of ships and three-dimensional effects on the prediction of ship motions in a seaway.
(*g*) See (h).
(*h*) **Computations of Three-Dimensional Ship-Motions with Forward Speed,** M. S. Chang, *2nd Intl. Conf. Numerical Ship Hydrodynamics*, Univ. California, Berkeley, 1977.

333-10727-030-22

DYNAMICS OF BUOY-CABLE-BODY SYSTEMS

(*b*) Naval Air Development Center.
(*c*) Dr. Henry T. Wang, Hydrodynamics Branch.
(*d*) Theoretical/numerical; applied research.
(*e*) A FORTRAN IV computer program has been developed for the time domain analysis of the two-dimensional dynamic motions of general buoy-cable-body systems. A variety of shapes are used to model the surface buoy and intermediate bodies. The cable is modeled by a series of finite elements.
(*f*) Completed.
(*g*) The computer program has been extended to include a more general formulation for the surface buoy. Techniques for efficient use of the program have been developed.
(*h*) **Technique for Efficient Time-Domain Analysis of Complete Buoy-Cable Systems,** H. T. Wang, *ASME Paper 78-WA/OCE-6*, Dec. 1978.

333-11476-520-22

AIR CUSHION CRAFT ADDED DRAG IN WAVES

(*b*) Naval Material Command.
(*c*) Michael B. Wilson, High Performance Craft Powering Branch.
(*d*) Experimental and engineering analysis; applied research.

(*e*) Review the state-of-the-art technology for determining added drag experienced by marine air cushion craft operating in waves. A main purpose of this effort is to establish what is known about ACV and SES added drag, experimentally and theoretically, and what problems exist with present methods of estimating added drag for design and with designing model experiments to measure useful drag data.

(*g*) A considerable amount of model added drag exists in the available literature, large uncorrelated with full-scale test results. Current methods of estimating added drag in waves are essentially empirical. There are mixed indications of how various elements of the vehicle subsystems should be scaled, particularly cushion stiffness properties and skirt materials. Lack of Froude-scaled frequency response is demonstrated for several characteristics of the lift support system, skirt/seal system, and air distribution characteristics. Available theoretical approaches to added drag are limited to simplified versions of the complete problem, and offer little direct help for estimation purposes.

333-11477-550-00

AIR EMISSION FOR REDUCTION OF PROPELLER CAVITATION EROSION

(*c*) M. L. Miller, Propulsor Technology Branch.

(*d*) Experimental; applied research.

(*e*) This was a preliminary experiment to determine if cavitation erosion of marine propellers could be eliminated or reduced by emitting air from points upstream of the propeller so that it would flow into the cavities on the blades and reduce the impact intensity of the collapsing cavities. A manganese bronze propeller was subjected to a severe cavitating condition in the cavitation tunnel using a thick strut ahead of the propeller to produce a wake which resulted in an unsteady cavitation pattern on the propeller blades. Air jets were attached to the strut so that air could be introduced into the flow. Sequences of high-speed photographs were used to record the growth and collapse of the cavities. Soft aluminum discs were inserted in one blade to reduce the time required for the experiment.

(*f*) Discontinued.

(*g*) With no air, the aluminum insert was severely eroded in 10 minutes. More than five hours were required to erode a manganese bronze insert to approximately the same degree. With the maximum amount of air available only a very slight amount of erosion was observed. A smaller volume of air or injecting the air at other than the optimum location resulted in less reduction of the erosion. This demonstrated that air injected into the flow ahead of a propeller can significantly reduce the amount of cavitation erosion.

333-11478-520-22

HYDRODYNAMIC BASIS FOR ROLL MOTION STABILIZATION

(*b*) Naval Sea Systems Command.

(*c*) G. G. Cox, Surface Ship Dynamics Branch.

(*d*) Theoretical, applied research, design.

(*e*) A hydrodynamic technology base for designing and evaluating roll motion stabilizers for naval ships is developed.

(*f*) Completed.

(*g*) Procedures for designing and evaluating bilge keels, antiroll fins and antiroll tanks are developed and validated. Fin controller characteristics can likewise be developed by implementation of numerical techniques now within the state-of-the-art.

(*h*) **Hydrodynamic Design Basis for Navy Ship Roll Motion Stabilization,** G. G. Cox, A. R. Lloyd, *Trans. Soc. Naval Architects and Marine Engrg.* **85**, pp. 51-93, 1977.

333-11479-530-22

HYDROFOIL WAVEMAKING DRAG AT LOW FROUDE NUMBERS

(*b*) Naval Sea Systems Command, Advanced Naval Vehicles Concept Evaluation (ANVCE) Project, and Naval Material Command.

(*c*) Michael B. Wilson, High Performance Craft Powering Branch.

(*d*) Experimental and theoretical; applied research.

(*e*) Determination of the wavemaking resistance characteristics of a submerged hydrofoil in the low Froude number regime important for possible very large chord lifting foil applications.

(*g*) Towing basin experiments have been performed using a faired flat plate hydrofoil of aspect ratio 4 at seven submergence depths and chord Froude numbers ranging from 0.5 to 3.5. The wave drag was deduced by subtracting the measured drag at the deepest submergence. To provide a developing capability for analytical prediction of hydrofoil performance, the lifting line theory by T. Y. Wu has been implemented in computer calculations for the wave drag and lift correction at any Froude number and submergence.

(*h*) **Low Froude Number Hydrodynamic Performance of a Flat Plate Hydrofoil,** M. B. Wilson, J. R. Kelley, *DTNSRDC Departmental Report SPD-743-01*, Dec. 1976.

Lifting Line Calculations for Hydrofoil Performance at Arbitrary Froude Number and Submergence, Part 1: Foxed Shape Elliptical Circulation Distribution, M. B. Wilson, *DTNSRDC Departmental Report DTNSRDC/SPD-0839-01*, June 1978.

333-11480-520-22

MINIMUM FREEBOARD OF CONVENTIONAL SURFACE SHIPS

(*b*) Naval Sea Systems Command.

(*c*) N. K. Bales, Surface Ship Dynamics Branch.

(*d*) Theoretical, applied research, design.

(*e*) A procedure which yields required freeboard to minimize adverse effects of deck wetness while also minimizing attendant increases in structural weight and construction cost is developed. Performance limits associated with the ship's underwater body and the wave environment have been derived.

(*f*) Completed.

(*g*) Results have been synthesized into a design procedure.

(*h*) **Minimum Freeboard Requirements for Dry Foredecks: A Design Procedure,** N. K. Bales, *Proc. SNAME STAR '79 Symposium*, Houston, Apr. 1979.

333-11481-520-22

OPERATIONAL SHIP DYNAMICS

(*b*) Naval Sea Systems Command.

(*c*) S. L. Bales, Surface Ship Dynamics.

(*d*) Applied research, development, operation.

(*e*) The use of hull dynamics (seakeeping) in ship operations is investigated. A methodology for providing guidance to avoid excessive ship motions and related events, such as keel slamming and bow wetness, is developed. Heavy weather operating conditions as well as ship performance criteria for avoiding structural damage and personnel performance degradation are identified based on operational experience with a typical surface ship.

(*f*) Completed.

(*g*) A hard copy catalog of heavy weather ship operator guidance is developed. Alternative seakeeping methodology implementation techniques are described.

(*h*) **Development of a Heavy Weather Operator Guidance Catalog for FF-1052, Class Ships,** S. L. Bales, E. W. Foley, *DTNSRDC Report SPD-0773-02*, 1979.

Ship Seakeeping Operator Guidance Simulation, S. L. Bales, E. N. Comstock, R. T. Van Eseltine, E. W. Foley, *Proc. Summer Simulation Conf.*, Toronto, July 1979.

333-11482-550-22

TIP VORTEX CAVITATION

(*b*) Naval Material Command and Naval Sea Systems Command.
(*c*) W. G. Souders, Special Systems Branch, and G. P. Platzer, Propulsor Technology.
(*d*) Experimental; applied research.
(*e*) An extensive literature study pertaining to the tip vortex viscous roll-up phenomenon and its alleviation has been recently concluded. Those alleviation concepts which appeared applicable to the marine propeller were highlighted and appropriate experimental investigations were recommended. The follow-on experimental program will evaluate the effectiveness (tip vortex cavitation and performance) of several of the recommended concepts, e.g., the bulbous tip (a selective increase in the wing tip thickness), a linear mass injection directly into the vortex core tip roughening, and the perforated tip. Initially, the work will be performed on a fixed, planar-lifting surface of elliptical plan form; adaptation to a propeller blade will come at a later stage.
(*f*) The initial experimental stage is scheduled to start in the late Spring 1979.
(*g*) No results available at this time.
(*h*) **Tip Vortex Cavitation Abatement with Application to Marine Propellers,** G. P. Platzer, W. G. Souders, *DTNSRDC Report 79/052* (in preparation).

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TENNESSEE VALLEY AUTHORITY, DATA SERVICES BRANCH, Knoxville, Tenn. 37902. Mr. Claude H. Smith, Branch Chief.

334-0261W-810-00

PINE TREE BRANCH WATERSHED

For summary, see Water Resources Research Catalog **6,** 2.1304. Hydrologic measurements discontinued June 1978. Forest Management activities continuing.

334-00765-810-00

EVAPORATION IN THE TENNESSEE BASIN

(*d*) Field investigation; applied research.
(*e*) To provide data for estimating reservoir losses and derive a general rule, applicable to the Basin, permitting computation of evaporation from pans at six locations in Basin, together with standard meteorological readings.
(*h*) Results published in monthly and annual bulletins, *Precipitation in Tennessee River Basin* (Project 00768).

334-00768-810-00

PRECIPITATION IN TENNESSEE RIVER BASIN

(*d*) Field investigation; basic research.
(*e*) Precipitation data from a network of about 390 gages including 110 owned by other agencies is collected and published for purposes of operating the TVA reservoir system for flood control, power, navigation, recreation, water supply and quality. Information is also used for planning, design, storm studies, and to fill requests.
(*h*) Monthly and annual bulletins, *Precipitation in Tennessee River Basin.*

334-00769-860-00

RESERVOIR AND STREAM TEMPERATURES

(*d*) Field investigation; basic research.
(*e*) Collection of basic water temperature information at selected sites in reservoirs and streams for use in power plant siting, aquatic or biological investigations, industrial plant siting, or other studies. Variations in temperature from surface to bottom in selected reservoirs are determined by soundings, and by continuous recording gages in selected natural streams. Periodic observations are made at gaging stations.

334-00771-350-00

GALLERY DRAINAGE IN LARGE DRAINS

(*d*) Field investigations; design.
(*e*) Weirs are placed in main galleries and drainage measured as check on tightness and stability.

334-00785-350-00

SEDIMENTATION OF EXISTING RESERVOIRS

(*d*) Field investigation; design and operation.
(*e*) Selected ranges in reservoirs are probed and sounded, volumetric samples are collected and analyzed, quantity and distribution of sediment are computed to determine deposition by stream, probable life of reservoir, effect of sediment storage on navigation channels and sedimentation of down-stream reservoirs, and probable sedimentation in future reservoirs.
(*h*) **Sedimentation in TVA Reservoirs,** *Rept. No. 0-6693*, TVA, Feb. 1968.

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TENNESSEE VALLEY AUTHORITY, WATER SYSTEMS DEVELOPMENT BRANCH, Drawer E, Norris, Tenn. 37828. E. Ely Driver, Branch Chief.

335-07080-340-00

RACCOON MOUNTAIN–HYDRAULIC TRANSIENT STUDIES

(*d*) Field investigations.
(*e*) Measurements of water hammer and surges during initial operation and acceptance testing of the pump/turbines. Transient flows, pressures, surge magnitude, gate openings, shaft torque, etc., will be measured and recorded simultaneously during simulated load rejection and pump power failure.

335-08570-860-00

FORT PATRICK HENRY REOXYGENATION STUDIES

(*d*) Field investigation; experimental.
(*e*) Tests on the performance of small oxygen bubble reaeration technique for increasing the dissolved oxygen in turbine discharges. At a pilot setup at Fort Patrick Henry Dam, measurements were made of oxygenation uptake efficiency as a function of water flow rate, oxygen flow rate, placement of the oxygen bubble generators and their pore size. Flows up to 4400 cfs were used. Calculations of cost of a full scale system and its sensitivity to variations in the design were made.
(*f*) Completed.
(*g*) Laboratory and field investigations yielded design data for the small oxygen bubble technique for turbine discharge reoxygenation. At least for this specific site, performance and cost data were compiled.
(*h*) **Evaluation of Small-Pore Diffuser Technique for Reoxygenation of TVA Releases at Fort Patrick Henry Dam,** T. G. Fain, *TVA Division of Water Resources Report No. Wm28-1-32-100*, Oct. 1978.

335-08575-800-00

DEVELOPMENT OF WATER RESOURCES MANAGEMENT METHODS

(*c*) Walter O. Wunderlich, Supervisor, Water Management Methods Staff.
(*d*) Theoretical; development.
(*g*) A weekly planning model has been developed that can find end-of-week storage levels for eighteen reservoirs and weekly average discharges for 42 reservoirs. The solution technique is dynamic programming. It minimizes a system performance index that includes consideration of navigation, flood control, power generation, recreation and water quality. A report is available. An enhanced stochastic weekly planning model and hourly models are under

development. Some applications to planning problems have been made.

(*h*) **Weekly Multi-Purpose Planning Model for the TVA Reservoir System,** *TVA WMMS Report A-11*, 211 p., 1977. Write to (c).

335-10735-340-00

SEQUOYAH AND WATTS BAR NUCLEAR PLANTS–RHR SUMP VORTEX STUDIES

(*d*) Experimental model study for design.
(*e*) Prior to licensing the efficacy of the Residual Heat Removal system must be demonstrated. This is accomplished with the use of 1:4 scale model of the containment structure and the RHR sump. Approach flow geometries are developed which result in no air-entraining vortices at the sump.
(*f*) Sequoyah model: completed. Watts Bar model: active.
(*g*) Modifications to the sump and approach flow geometry were made for the Sequoyah design to prevent the formation of air-drawing vortices at the sump. The hydraulic efficacy of anti-vortex devices was demonstrated. As a result, the Watts Bar RHR sumps were relocated and model tests of their efficacy were initiated.
(*h*) An internal TVA report covering the results of the Sequoyah model tests was issued to the Division of Engineering Design.

335-10736-330-00

PICKWICK LANDING NAVIGATION LOCK STUDY

(*d*) Experimental model study for design.
(*e*) A new navigation lock is to be added at the Pickwick Landing Dam. The new lock will be 110 × 1000 feet long with a maximum lift of about 65 feet. This will be the longest lock on the Tennessee River and it will be designed with TVA's multi-port filling and emptying system. The 1:25 scale model of the upstream approach, the lock chamber, and the downstream approach will be used to check the adequacy of the filling and emptying system. Transient pressures, surges, waves, and hawser forces will be measured. The object of the study is to minimize lock filling and emptying times and also the water turbulence and hawser forces.
(*f*) Completed.
(*g*) Hydraulic features of the multiport lock filling and emptying system were examined and best values were developed for the critical parameters, e.g., the total mulitport area to culvert cross-section area ratio, the length multiport region to lock chamber length ratio, and the valve opening time to lock filling time ratio. Special anti-vortex hoods were developed for the intakes, valve cavitation potential was evaluated, and airtight bulkhead slot fillers were devised to prevent air entrainment. Culvert pressures, lock chamber hawser forces and wave amplitudes, and discharge velocities, wave heights and hawser forces in the downstream channel were measured.
(*h*) Several internal TVA reports were issued covering the results of these tests.

335-10737-850-00

SURVIVAL OF LARVAL FISH IMPINGED ON FINE MESH SCREENS

(*d*) Experimental biological laboratory and field study–basic research.
(*e*) Basic data is sought on the feasibility of screening larval fish from a pump intake to mitigate adverse impact on the fish population. Measurements were made in the laboratory of the degree of entrainment and mortality of fish impinged on fine mesh screens by flow normal to the screen for different time intervals and approach velocities. Screens with openings from 0.5-2 mm were tested under velocities from 0.5-2 fps with larval fish sized from 4-8 mm for impingement times of up to 8 minutes. Several fish species were tested. Also panels of fine mesh screens were mounted on an existing condenser cooling water intake for a coal fired steam generating plant equipped with standard vertical traveling screens, and the size and numbers of impinged larval fish were analyzed and compared to the laboratory tests.
(*f*) Completed.
(*g*) Results differed widely for different species of larvae, but in general high survival of larvae was obtained when the screen openings were about 1 mm or less and the approach water velocities were 1 fps or less and the fish remained impinged less than 4 minutes.
(*h*) **Investigations on the Protection of Fish Larvae at Water Intakes Using Fine Mesh Screening,** D. A. Tomljanovich, et al., *TVA Division of Forestry, Fisheries, and Wildlife Development Technical Note B-22*, Feb. 1977.

335-10738-850-00

MODIFICATIONS OF VERTICAL TRAVELING SCREENS TO IMPINGE AND RELEASE UNHARMED LARVAL FISH

(*d*) Experimental, biological, laboratory tests for design.
(*e*) A laboratory apparatus has been constructed by means of which the vertical motion of traveling screen baskets can be simulated. The test basket with fine mesh screening material is made to move through a stream of water, through the air and through a circular, emptying motion. The mortality of larval fish will be studied for different species, different screen mesh sizes, varying approach velocities and simulated screen traveling times. The effects of stress points like impingement, removal from the stream, washing off the screen, and dumping into a return sluice will be studied separately. Modifications to the screening system will be made to obtain improved larval fish mortality.
(*g*) Flat and semi-circular screen-baskets with and without water-holding fish-buckets were tested with polyester screens with 0.5 mm openings and varying approach velocities. Large variation in larvae survival was obtained depending on the species, age, and size. In general, results indicated that larvae could be impinged, removed with the traveling screen from the water, washed off the screen surface into wet buckets, and tipped or flushed from the buckets into sluices for return to the natural environment with high degree of survival.
(*h*) **Biological Evaluation of Fish Handling Components of a Water Intake Screen Designed to Protect Larval Fish,** D. A. Tomljanovich, J. H. Heuer, TVA Division of Forestry, Fisheries and Wildlife Development, 1979.

335-10740-870-00

THERMAL DISPERSION AND FLUID DYNAMICS MODELING

(*b*) Environmental Protection Agency.
(*c*) W. R. Waldrop, P.O. Drawer E, Norris, Tenn. 37828.
(*d*) Theoretical; applied research.
(*e*) Computer models are being developed for analyzing the effects of thermal discharges from steam plants on temperatures and velocities in the receiving body of water. A three-dimensional, unsteady model provides relatively fine scale resolution within approximately a 10-kilometer reach of the river. A two-dimensional, unsteady model which also includes natural heating and cooling effects as well as thermal discharges is used to analyze entire reservoirs or long reaches of rivers.
(*g*) The three-dimensional model has been used in the analysis of intake and discharge flow fields of several steam-electric generating plants. The two-dimensional model has been applied to the thermal analysis of an embayment on which a proposed nuclear plant would be situated. Other applications in progress include simulations of a deep storage reservoir and the GRH flume at the U.S. Army Corps of Engineers' Waterways Experiment Station at Vicksburg, Miss.
(*h*) **Analysis of the Thermal Effluent from the Gallatin Steam Plant During Low River Flows,** W. R. Waldrop, F. B. Tatom, *Tech. Rept. No. 33-30*, June 1976.

335-10775-850-00

INTAKE AVOIDANCE TESTS WITH LARVAL FISH

(*d*) Experimental biological laboratory tests–basic research.
(*e*) A test flume is used to study the capability of larval fish of different species to avoid impingement on a slotted, wedge-wire screen when the approach velocity is parallel to the screen surface and flow is provided by passing the screen. Screens are tested in both the horizontal and vertical positions, with different slot widths and for different bypass flow ratios.
(*g*) Tests with both horizontal and vertical, flat, fixed wedge-wire screens with approach flow parallel to the screen surface showed good screen avoidance for several species of larval fish as long as the velocity through the screen was about 0.5 fps and the by-pass flow velocity was 1 fps or larger. Large variations were obtained for different species of larvae.
(*h*) **A Study on the Protection of Fish Larvae at Water Intakes Using Wedge-Wire Screening,** J. H. Heuer, et al., *TVA Division of Forestry, Fisheries, and Wildlife Development Technical Note B-26*, Aug. 1978.

335-11485-330-00

PICKWICK LANDING LOCK APPROACH NAIVIGATION MODEL

(*d*) Experimental model study for design development.
(*e*) A 1:90 scale topographic model of the downstream approach to the new main lock at Pickwick Landing Dam has been constructed and is undergoing tests. The flow patterns in the lock approach resulting from hydroturbine and spillway discharges have been verified in the model by velocity measurement in the field for high and low flow rates. A radio controlled scale model tow is used to evaluate the navigation conditions in the lock approach. The purpose of the investigations was to minimize excavation and at the same time assure adequate navigation conditions.

400-11486-350-00

PLUGGING TEST ON FIXED INTAKE SCREENS WITH SMALL OPENINGS

(*d*) Experimental field investigation.
(*e*) Site specific test on the plugging potential and backwashing ability of fixed vertical and horizontal screens with openings of 1 mm and less placed in a river with flow parallel to the screen surface.
(*f*) Completed.
(*g*) Tests revealed that site specific detritus, algae and weeds could quickly plug the fixed screens with openings of about 1 mm and through flow velocity of about 1 fps, but also that backwash water propelled with compressed air at velocities of about 3-5 fps could clean the screens in a few seconds. Backwashing intervals as short as one-half hour were needed at times.
(*h*) Two internal TVA reports have been issued describing the tests and the results.

335-11487-340-00

BELLEFONTE NUCLEAR PLANT–RHR SUMP VORTEX STUDY

(*d*) Experimental, applied research, laboratory study for design.
(*e*) A 1:10 scale model of the containment sturcture and the two residual heat removing system sumps is under construction. The purpose of the model is to ascertain adequate hydraulic performance of the sump, e.g., to develop the approach flow geometry and needed anti-vortex devices so that a low headloss sump flow results free of air-entraining vortices.
(*f*) Under construction.

335-11488-860-00

FIELD MEASUREMENTS OF RESERVOIR HYDRODYNAMIC PROCESSES

(*c*) W. R. Waldrop, P.O. Drawer E, Norris, Tenn. 37828.
(*d*) Field investigation.
(*e*) Instrumentation and procedures have been developed for performing field studies of the many factors affecting the dispersion phenomenon in reservoirs. Dye diffusion studies have been undertaken to determine the horizontal and vertical dispersion coefficients. The impact of reservoir thermal stratification on the dispersion process has been investigated with some success. The significant influence of wind on the vertical mixing and hence the location of the thermocline has stimulated the planning of field experiments for investigating the wind-induced mixing process. A study of the thermal and hydrodynamic coupling of the main-channel segment of a reservoir with its overbanks and embayments will also be conducted to provide a better understanding of the temperature structure of the reservoir.

335-11489-890-00

AN AIR BUBBLE CONTROL TECHNIQUE IN HORIZONTAL AQUIFERS FOR COMPRESSED AIR ENERGY STORAGE

(*c*) W. R. Waldrop, P.O. Drawer E, Norris, Tenn. 37828.
(*d*) Development with experimental verification.
(*e*) As the electric power industry increases its reliance on large nuclear and coal-fired power stations, the need for peaking plants to meet the short-term load fluctuations increases. One concept is to store energy generated during periods of low demand for use during periods of high demand. A promising method is to store this energy as compressed air underground in aquifers. The concept of using structural domes to control compressed air stored in aquifers is a straightforward extension of practices of the natural gas industry. This project will develop and test a method of controlling the movement of an air bubble in an aquifer which lacks a structural dome. The numerical models which are being developed will be tested by simulating the behavior of an air bubble in a laboratory aquifer with known properties.

335-11490-820-00

COMPUTATION OF GROUNDWATER FLOW AND WATER QUALITY NEAR WASTE DISPOSAL PONDS

(*c*) W. R. Waldrop, P.O. Drawer E, Norris, Tenn. 37828.
(*d*) Applied research for environmental analysis.
(*e*) Perform various levels of screening, testing and validation of currently available aquifer flow and mass transport models. Modification and further model development will be undertaken as necessary for model application to transport problems in the TVA region. A series of models having a range of complexity and capability will be the product of the study.

335-11491-340-00

REAL-TIME COMPUTATION AND PREDICTION OF POWER PLANT EFFECTS ON RIVER TEMPERATURES

(*c*) W. R. Waldrop, P.O. Drawer E, Norris, Tenn. 37828.
(*d*) Applied research; for operation.
(*e*) Power plant effects on river temperatures are determined by measurements of plant and river parameters and computations using models of discharge system performance. Central to this method are models of diffuser performance developed using physical model and field data and models of unsteady river flows. Measured data for computation of plant effects are dam discharges, river temperature after discharge mixing, discharge flow and discharge temperature. Predictive models of plant effects on river temperature are also being developed, relying on predictions of plant operation, river flows and meteorology.
(*h*) **A Technique for Determining the Optimum Mode of Cooling at the Browns Ferry Nuclear Plant,** W. L. Harper, W. R. Waldrop, *TVA Division of Water Management, Water*

Systems Development Branch Report No. 63-53, Nov. 1975.

An Operational Procedure for Predicting the Most Economical Use of Condenser Cooling Modes, W. L. Harper, W. R. Waldrop, *Proc. Waste Heat Management and Utilization Conf.*, Miami Beach, Fla., May 1977.

Assessment of Water Temperature Monitoring at the Browns Ferry Nuclear Plant, C. D. Ungate, *TVA Division of Water Management, Water Systems Development Branch Report No. WM28-1-67-101*, Aug. 1978.

335-11492-340-00

MODELING OF THERMAL DISCHARGE DIFFUSERS

(*c*) W. R. Waldrop, P.O. Drawer E, Norris, Tenn. 37828.

(*d*) Experimental, theoretical and field investigations; applied research and design.

(*e*) The performance of multiport diffuser systems for the discharge of thermal effluents from steam-electric generating plants is studied theoretically, experimentally and in the field. Buoyant and momentum length scales are developed which may be used to describe diffuser performance over a wide range of operating conditions. Designs which take advantage of site-specific characteristics have been developed for sevral nuclear plants. A generic study of the performance of diffusers of finite length in the momentum-buoyant transition is being conducted, which will elucidate the role of several nondimensional parameters in governing diffuser performance.

(*g*) Generally useful nondimensional formulations for predicting diffuser performance have been developed. Diffuser designs for several power plants have been completed.

(*h*) **Submerged Multiport Diffuser Analysis and Design for Bellefonte Nuclear Plant,** C. W. Almquist, C. D. Ungate, *Report No. WM28-1-88-003*, TVA, Water Systems Development Branch, Norris, Tenn., 1977.

Submerged Multiport Diffuser Analysis and Design for Hartsville Nuclear Plant, C. W. Almquist, *Report No. WM28-1-89-100*, TVA, Water Systems Development Branch, Norris, Tenn., 1978.

Model Study and Analysis of Sequoyah Nuclear Plant Submerged Multiport Diffuser, L. N. McCold, *Report No. WM28-1-45-103*, TVA, Water Systems Development Branch, Norris, Tenn., 1979.

Field and Model Results for Multiport Diffuser Plume, C. W. Almquist, C. D. Ungate, W. R. Waldrop, *Verification of Mathematical and Physical Models in Hydraulic Engineering, Proc. 26th Ann. Hydraulics Div. Specialty Conf., ASCE*, 1978.

335-11493-860-00

SYSTEM-WIDE WATER TEMPERATURE ANALYSIS OF THE TENNESSEE AND CUMBERLAND RIVERS

(*c*) W. R. Waldrop, P.O. Drawer E, Norris, Tenn. 37828.

(*d*) Theoretical; applied research.

(*e*) A system-wide model of water temperatures based on heat balance formulations with both Langrangian and Eulerian flow coordinates is being developed. Currently available one-dimensional flow routing techniques are being combined with new formulations for overbank and embayment, flow patterns, vertical heating and wind mixing processes. Hourly scale heat balance, flow and mixing mechanisms are used in portions of the temperature model where diurnal fluctuations are important. The model system will include several spatial and temporal scales, depending on the hydrography and hydraulic characteristics of the river reach or reservoir segment. Applications of the results include assessing the far-field thermal impacts of dam releases and power plant discharges; interpreting biological sampling data, and separating natural temperature variability from thermal discharge monitoring data.

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PROJECT REPORTS FROM CANADIAN LABORATORIES

ACRES CONSULTING SERVICES LIMITED, 5259 Dorchester Road, Niagara Falls, Ontario L2E 6W1, Canada. Dr. I. K. Hill, Head, Hydraulic Department.

400-10496-350-87

KPONG DIVERSION MODEL

(*b*) Volta River Authority, Ghana.
(*c*) Mr. G. H. Michell.
(*d*) Experimental, for design purposes.
(*e*) Model study to verify the hydraulic adequacy of the diversion channel, including head losses, local velocities in areas requiring erosion protection, and to select the channel geometry resulting in minimum excavation. Erosion protection was specified based on velocity tests.
(*f*) Study complete, report submitted to client.

400-11267-340-73

ST. MARY'S HYDRAULIC HEAD RACE MODEL

(*b*) Great Lakes Power Corporation Limited.
(*c*) Mr. L. H. Anderson.
(*d*) Experimental, for design purposes.
(*e*) Model study to define hydraulic parameters, and finalize approach channel geometry and ice handling facilities for a low-head, bulk turbines plant. The confined nature of the site required a complex assymetrical approach.

400-11268-390-70

ICE MANAGEMENT WITHIN BRIDPORT INLET

(*b*) Petro-Canada, Calgary, Alberta.
(*c*) Mr. R. G. Tanner.
(*d*) Develop design criteria and determine concept feasibility.
(*e*) Study to identify the ice management problems at Bridport Inlet, which is the proposed northern terminal for the Arctic Pilot Project, to recommend the potential solutions and to select the most feasible solution for implementation. A comprehensive study of ice conditions, based on climatologic and oceananographic data, and of ice management problems which were compared with the practical results from other operators.
(*f*) Study complete. Report submitted to client.
(*g*) A conceptual system was recommended for more detailed investigation.

400-11269-340-70

SUBMERGED JET OF THERMAL DISCHARGE MODEL

(*b*) Petro-Canada, Calgary, Alberta.
(*c*) Mr. R. G. Tanner.
(*d*) Experimental, for obtaining basin design criteria.
(*e*) The study model is an insulated flume with transparent side walls, with a recirculating cold water flow and chilled air circulation over the water, equipped with extensive temperature measurement and ice thickness measurement capability. The study is concerned with heat transfer from the underflow to the ice cover at various velocities and water temperatures, and to demonstrate the effect of submerged jets on the ice thickness.

400-11270-390-73

WOLSUNG PUMP INTAKE MODEL

(*b*) Korea Electric Company.
(*c*) Mr. R. W. McKay.
(*d*) Experimental, for design purposes.
(*e*) Model study to test flow conditions in an approach channel including forebay and pump bays, under different pump and passage operations, and to test modification proposed to avoid vortex formation and limit swirl. The original geometry was modified to improve entrance conditions and eliminate air entraining vent.
(*f*) Study complete. Report submitted to client.

400-11271-870-70

THOMAS HILL PRECIPITATOR MODEL

(*b*) C. E. Walther Inc.
(*c*) Dr. S. Bhan.
(*d*) Experimental, for design purposes.
(*e*) A model of an electrostatic precipitator was constructed including appropriate ductwork in order to study the airflow characteristics through the model and to design the flow control device needed for an acceptable flow distribution and pressure drop.

400-11272-870-70

GREEN RIVER STACK MODEL

(*b*) American Air Filter.
(*c*) Dr. S. Bhan.
(*d*) Experimental, for design purposes.
(*e*) A model of a duct system was built to study the gas flow conditions. The tests were made using warm air to heat flux gases above their dew point.
(*f*) Study complete. Report submitted to client.

400-11273-870-70

MILL CREEK FOUR SCRUBBER MODEL

(*b*) American Air Filter.
(*c*) Dr. S. Bhan.
(*d*) Experimental for design purposes.
(*e*) A model of a sulfur dioxide scrubber was built to study the airflow conditions. The study defined the conditions expected during operation.
(*f*) Study complete. Report submitted to client.

400-11274-870-75

AMOCO PRECIPITATOR MODEL

(*b*) Fruco Engineers.
(*c*) Dr. S. Bhan.
(*d*) Experimental, for design purposes.
(*e*) A model of an electrostatic precipitator was constructed including appropriate ductwork in order to study the airflow characteristics through the model and to design the flow control device needed for an acceptable flow distribution and pressure drop.

400-11275-390-75

PHILIPPINE PUMP INTAKE MODEL

(*b*) Burns and Roe Incorporated.
(*c*) Mr. R. E. Mayer, Acres American Inc., Consulting Engineers, Liberty Bank Building, Main at Court, Buffalo, N.Y. 14202.
(*d*) Experimental, for design purposes.

(*e*) The pump intake model consisted of a 1:12-scale plastic model of an intake for two pump bays, including accessories for water supply and measurements. The study defined the intake geometry and flow parameters within the intake and pump suction bell under the requirement of an evenly distributed flow to each pump.
(*f*) Study complete. Report submitted to client.

400-11276-400-10

CHESAPEAKE BAY HYDRAULIC MODEL

(*b*) U.S. Army Corps of Engineers.
(*c*) Dr. J. W. Hayden, Acres American Inc., Consulting Engineers, Buffalo, N.Y. 14202.
(*d*) Experimental, for a comprehensive study of water utilization and control in Chesapeake Bay basin.
(*e*) The Chesapeake hydraulic model is the biggest estuary model used for applied research. The model has an area of 3.26 ha protected by a shelter of about 6 ha. The study objective is to obtain the basic data required for the Chesapeake Bay development, taking account of water supply, navigation, fisheries and recreation, and for control of floods, noxious weeds, water pollution and water quality. Among the main research questions are the natural regime of salinity, currents, movements of the saltwater-freshwater interface, as well as the effects of various existing and projected plants and water uses such as navigation, underwater outfalls, nuclear and fuel power plants, and port facilities. The model construction and calibration is complete and the proposed studies in progress.

400-11277-870-70

HARVARD UNIVERSITY ELECTROSTATIC PRECIPITATOR

(*b*) Belco Pollution Control Corporation.
(*c*) Dr. S. Bhan.
(*d*) Experimental, for design purposes.
(*e*) The airflow model consisted of a 1:16-scale model of a precipitator with associated transition pieces connected to an induced draft fan flow. Tests were made on the gas flow distribution, in the entire treatment zone, to minimize pressure drops and to locate and minimize potential areas of dust deposits. The study confirmed basin design adequacy and recommended some modifications.
(*f*) Study complete. Report submitted to client.

ALBERTA RESEARCH COUNCIL, TRANSPORTATION AND SURFACE WATER ENGINEERING DIVISION, 303 Civil-Electrical Building, University of Alberta, Edmonton, Alberta, Canada, T6G 2G7. Dr. S. Beltaos, Research Officer. (Note: The Council coordinates the Alberta Cooperative Research Program in Transportation and Surface Water Engineering. Major participants in this program, in addition to Council, are two Provincial Government Departments–Alberta Environment and Alberta Transportation–and the Department of Civil Engineering, University of Alberta.)

401-07886-370-96

ICE FORCES ON BRIDGE PIERS

(*b*) Alberta Transportation.
(*c*) A. W. Lipsett.
(*d*) Field and theoretical investigation; applied research.
(*e*) Measurement of dynamic forces during spring break-up on two instrumental piers in different rivers; supplemementary pier vibration tests to determine dynamic response characteristics such as stiffness, natural frequency and damping.
(*g*) Measurements over twelve seasons have indicated maximum instantaneous apparent pressures of up to 2.4 MPa on a vertical cylindrical pier and up to 1.2 MPa on a pier inclined 23° from the vertical. It has become evident that use of an apparent pressure for an inclined pier is not appropriate; an alternative method of analysis has been formulated to account for ice failure modes other than crushing. Recently, an analysis of the dynamic response of piers to typical ice loading histories was initiated. To determine the dynamic pier response characteristics that are necessary for this type of analysis, a field program for pier vibration tests was instigated.
(*h*) **Mode of Failure and the Analysis of Ice Loads on Bridge Piers,** R. Gerard, *Proc. IAHR Symp. Ice Problems, Part 1*, pp. 335-348, Lulea, Sweden, Aug. 1978.

401-10761-300-96

ICE THICKNESS DOCUMENTATION

(*b*) Alberta Transportation, Alberta Environment.
(*c*) P. F. Doyle.
(*d*) Field investigation; applied research.
(*e*) Ice thickness measurements are being carried out at selected sites in an effort to determine ice thicknesses which can be generated by different processes in a river such as clear ice, snow ice, aufeis and frazil ice formation.
(*g*) The results to date have indicated that ice flows much thicker than "usual" may occur at spring breakup due to the latter two processes. The possibility of such formations occurring upstream of a bridge site must be assessed during design.

401-10762-300-96

FREEZE UP AND BREAKUP OF RIVER ICE

(*b*) Alberta Environment, Alberta Transportation.
(*c*) S. Beltaos, P. F. Doyle.
(*d*) Field investigation; applied research.
(*e*) Observations of ice freeze up and breakup phenomena at selected river sites in Alberta; emphasis on documentation of ice jam characteristics.
(*g*) About ten ice jams have been documented to date and the data are being analyzed within the frameworks of available theoretical models; despite the many uncertainties involved in analyzing field data on ice jams, the results have, so far, been encouraging. In addition to quantitative documentations, qualitative descriptions of freeze up and breakup processes have been obtained at selected river sites over the past few years.
(*h*) **Field Investigations of River Ice Jams,** S. Beltaos, *Proc. IAHR Symp. Ice Problems*, Part 2, pp. 335-371, Lulea, Sweden, Aug. 1978.
[Discussion of **Equilibrium Thickness of Ice Jams,** by J. C. Tatinclaux, S. Beltaos, *Proc. ASCE, J. Hydraulics Div.* **104,** HY4, pp. 578-581, Apr. 1978.
1978 Breakup in the Vicinity of Fort McMurray and Investigation of Two Athabasca River Ice Jams, P. F. Doyle, Transportation and Surface Water Engrg. Div., Alberta Research Council, *Internal Rept. SWE-78-05*, 1978.

401-10763-350-00

HYDRAULICS OF RIVER STRUCTURES

(*b*) Alberta Transportation, Alberta Environment.
(*c*) S. Beltaos, P. F. Doyle.
(*d*) Field and experimental investigation; applied research.
(*e*) Flow and scour measurements at bridges and river training works during flood conditions. To supplement field findings, laboratory experiments are occasionally carried out.
(*g*) Data have been collected at several sites over the past decade but have yet to be analyzed.

401-10764-350-96

RIVER MORPHOLOGY

(*b*) Alberta Environment, Alberta Transportation.
(*c*) S. Beltaos, P. F. Doyle.
(*d*) Field investigation; applied research.
(*e*) Hydraulic and geomorphic characteristics of Alberta rivers are being documented under a continuing, long term, field program. Where possible, the effects of changes in river regime are investigated in detail.

(*g*) Data have been obtained in a number of rivers in Alberta and some analysis has been carried out.

401-10765-200-96

MIXING PROCESSES IN NATURAL STREAMS

(*b*) Alberta Environment.
(*c*) S. Beltaos, A. W. Lipsett.
(*d*) Field and theoretical investigation; applied research.
(*e*) Tracer tests in representative river types of Alberta for evaluating transverse and longitudinal mixing characteristics under both open-water and ice-covered conditions. Development of analytical and numerical techniques for pertinent engineering predictions.
(*g*) Transverse mixing coefficients and longitudinal dispersion parameters have been evaluated at several river reaches. An explicit numerical algorithm, free of numerical diffusion, has been developed to simulate transient, two-dimensional mixing in rivers; comparisons with pertinent published data have been favorable. A critical re-examination of longitudinal dispersion data in rivers has resulted in a generalized dispersion model that seems capable of describing the available findings satisfactorily. This model is based on the postulate that the characteristic irregularity of natural streams has a single fundamental effect: to retard the onset of the "Fickian" dispersion process relative to prismatic channels of similar average dimensions and hydraulics; data analysis has confirmed this postulate: "retardation factors" of three to thirty times have been found. As part of this project, the Division participated in the Athabasca Blackfly Abatement Program; this program aims at an overall assessment of aquatic insecticide applications as a means of controlling blackfly larval populations, with special emphasis on the Athabasca River in Alberta.
(*h*) **Transverse Mixing in Natural Streams,** S. Beltaos, Transportation and Surface Water Engrg. Div., Alberta Research Council, *Internal Rept. SWE-78-01*, 1978.
An Interpretation of Longitudinal Dispersion Data in Rivers, S. Beltaos, Transportation and Surface Water Engrg. Div., Alberta Research Council, *Internal Rept. SWE-78-03*, 1978.
Triburary Mixing Characteristics Using Water Quality Parameters, A. W. Lipsett, S. Beltaos, Transportation and Surface Water Engrg. Div., Alberta Research Council, *Internal Rept. SWE-78-04*, 1978.
Mixing Processes in Natural Streams, S. Beltaos, *Proc. Transport Processes and River Modeling Workshop*, Burlington, pp. 1-23, Nov. 1978.
A Field Study of Longitudinal Dispersion, S. Beltaos, T. J. Day, *Canadian J. of Civil Engrg.* **5**, 4, pp. 572-585, 1978.

401-10766-300-96

FIELD INVESTIGATION OF A FRAZIL ICE HANGING DAM

(*b*) Alberta Environment, Alberta Transportation.
(*c*) S. Beltaos.
(*d*) Field investigation; applied research.
(*e*) A large accumulation of frazil ice under the ice cover was detected during the 1974-75 winter season in the Smoky River, some 40 km above its confluence with Peace River. Field investigations are in progress to elucidate the mechancis of formation and spring breakup, to evaluate effects on spring breakup in the Smoky and Peace Rivers and to assess the possible action against hydraulic structures of such frazil ice accumulations.
(*g*) Measurements revealed a local depression of the river bed with a maximum depth of 17 m below winter water levels, located immediately downstream of a rapids reach. At full size the hanging dam is 300 m long and has a maximum thickness of 15 m. In situ measurements of shear strength indicated that the frazil ice accumulation becomes stronger with height above the bottom of the accumulation. The shear strength is typically between 10 and 100 kPa and varies somewhat from season to season. Formation of the hanging dam is being monitored using a time lapse photography apparatus. Continuing spring breakup observations suggest that the dam may cause ice jamming extending up to 5 km upstream and a consequent local water level rise of up to 4 m above pre-breakup levels.

401-10767-300-96

DOCUMENTATION AND PROBABILITY ANALYSIS OF PAST ICE BREAKUP WATER LEVELS

(*b*) Alberta Transportation, Alberta Environment.
(*c*) R. Gerard, E. W. Karpuk.
(*d*) Field and theoretical investigation; applied research.
(*e*) Information on past breakup water levels at several sites in Alberta has been collected and a method of analysis developed to determine estimates of the probability distributions of annual peak breakup water levels at these sites. Such information is required in the design for ice action on bridge piers, and in assessing flood frequencies at locations prone to ice jams.
(*f*) Completed.
(*g*) A method of analyzing such historical data has been developed. Its application to information collected at one site has shown that the flood frequency curve is dominated by ice breakup water levels and not by summer flood water levels.
(*h*) **Probability Analysis of Historical Data on Ice Jam Floods,** R. Gerard, E. W. Karpuk, *ASCE, J. Hydraulics Div.*, in press.

401-10768-310-96

REGIONAL ANALYSIS OF NORTHERN ALBERTA FLOODS

(*b*) Alberta Transportation, Alberta Environment.
(*c*) R. Gerard.
(*d*) Field and theoretical investigation; applied research.
(*e*) Hydrometric records for some 60 catchments in Northern Alberta have been analyzed to determine the snowmelt flood and rain flood for each year of record. The differences between these flood populations have been assessed and indices of the populations related (i) catchment characteristics, and (ii) channel geometry using weighted regression analysis, have been determined.
(*f*) Completed; report is in progress.
(*g*) Analysis indicated that snowmelt and rainfall floods do form distinct populations. The use of weighted regression has allowed the inclusion of very short records in the analysis and explicit consideration of interstation correlation associated with both genuine and "lack of fit" errors. The separate regressions on catchment characteristics and on channel geometry allow two almost independent estimates of an index flood for an ungauged catchment.

401-10769-310-96

PEAK RUNOFF FROM SMALL CATCHMENTS

(*b*) Alberta Transportation, Alberta Environment.
(*c*) P. F. Doyle.
(*d*) Field investigation; applied research.
(*e*) Monitoring peak runoff due to snowmelt and rainfall at 43 gauged culvert sites in north-central Alberta. Investigation of culvert behaviour and confirmation of synthetic rating curves for these culverts under various flow conditions. Geomorphic channel characteristics are being measured in the hope of relating them to index floods of corresponding catchments.
(*g*) Peak runoff data collected during 1973-77 have been processed and partially analyzed. To date, no significant difference in magnitude between spring and summer runoff has been detected. Work is in progress to develop a suitable regression equation for estimating design floods, using readily available basin parameters and meteorological data.
(*h*) **Peak Runoff from Small Rural Watersheds in North-Central Alberta,** P. F. Doyle, Transportation and Surface Water Engrg. Div., Alberta Research Council, *Internal Rept. SWE-78-02*, 1978.

401-11278-220-96

ELBOW RIVER SEDIMENT TRANSPORT STUDY

(*b*) In cooperation with Department of Geography, University of Alberta, for Alberta Environment and Alberta Transportation.
(*c*) H. Hudson, M. C. Brown.
(*d*) Field investigation; applied research; for a Ph.D. thesis.
(*e*) The primary goal of this project is to collect and assess data on the spatial and temporal variation in the type and rate of sediment transport in a complex, intermediate size, watershed.
(*g*) In 1978, sediment load was sampled throughout the runoff season in the main river and active tributaries. Samples were obtained so as to characterize sediment load during three types of hydrologic events–spring melt, frontal rainstorms and local thundershowers. An effort was made to document both bed and suspended sediment loads and their variation across the stream; simultaneous depth and velocity data were also taken to enable correlation of sediment transport rates with corresponding hydraulic parameters.

401-11279-390-96

LOAD BEARING CAPACITY OF FLOATING ICE SHEETS

(*b*) Alberta Transportation.
(*c*) S. Beltaos, A. W. Lipsett.
(*d*) Field and theoretical investigation; applied research.
(*e*) Field tests and analytical studies are carried out to investigate the creep characteristics of floating ice sheets subjected to long term loads and to determine the causes of failure under such loading conditions; and the response of floating ice sheets to moving loads and determine safe speeds.
(*g*) Under stationary loads, the load bearing capacity of ice sheets is complicated by creep effects and thence by the loading history; conventional stress criteria of failure do not apply in this case. A search for a failure criterion that is independent of time and loading history revealed that the concept of a critical strain energy per unit volume of the material was successful in describing the results of prototype tests by both the Division and other investigators. To predict the response of a floating ice sheet to an arbitrary loading history a semi-empirical method has been formulated; this method is based on an empirical analysis of observed deflection-time curves for tests approximating the simplest loading history, that is, a constant load applied instantaneously. Using an empirical equation describing these curves and the principle of linear superposition, the deflection time curve for any loading history can be determined. Experimental documentation of the response of ice sheets to moving loads has been hampered by a lack of convenient methods for measuring deflection-time variations due to moving loads. A simple method, involving integration of the output of a sensitive slope transducer, has been developed and utilized to carry out field studies. To date, the results have provided strong support for a theory developed earlier by others.
(*h*) **A Strain Energy Criterion for Failure of Floating Ice Sheets,** S. Beltaos, *Canadian J. Civil Engrg.* **5,** 3, pp. 352-361, 1978.
An Empirical Analysis of the Creep of Floating Ice Sheets, S. Beltaos, A. W. Lipsett, *Natl. Research Council of Canada Workshop on the Bearing Capacity of Ice Covers*, Winnipeg, Oct. 1978.
Field Studies on the Response of Floating Ice Sheets to Moving Loads, S. Beltaos, *Natl. Research Council of Canada Workshop on the Bearing Capacity of Ice Covers*, Winnipeg, Oct. 1978.

UNIVERSITY OF ALBERTA, Department of Civil Engineering, Edmonton T6G 2G7, Alberta, Canada. Dr. N. Rajaratnam, Professor of Civil Engineering.

402-10282-300-90

ANALYTICAL RIVER MECHANICS

(*b*) National Sciences and Engineering Research Council Grant.
(*c*) Dr. Gary Parker.
(*d*) Theoretical; basic.
(*e*) Work on self-formed stable river width is complete. Research continues on the following topics: continuum mechanics treatment of bed and suspended load; turbidity currents; the equations of motion of migrating river bends.
(*g*) A model has been presented for determining self-formed channel geometry for silt-sand, and gravel streams. For the gravel case, rational regime relations and dimensionless hydraulic relations have been derived. A fundamental derivation of the Ashida-Michiue bed load equation from the equations of motion describing two-phase flow has been obtained.
(*h*) **Self-Formed Straight Rivers with Equilibrium Banks and Mobile Bed, Part 1, The Sand-Silt River,** G. Parker, *J. Fluid Mech.* **89,** 1, pp. 109-125.
Self-Formed Straight Rivers with Equilibrium Banks and Mobile Bed, Part 2, The Gravel River, G. Parker, *J. Fluid Mech.* **89,** 2, pp. 127-146.

402-10284-410-90

HYDRAULICS OF GROYNES

(*b*) NSERC of Canada.
(*c*) N. Rajaratnam, Professor.
(*d*) Basic and experimental.
(*e*) To understand the structure of the turbulent flow near groyne-like structures and to develop methods to predict flow pattern and erosion.
(*g*) A report is under preparation.

402-11280-300-90

MECHANICS AND HYDRAULICS OF ICE JAMS

(*b*) National Research Council of Canada.
(*c*) Dr. R. Gerard.
(*d*) Experimental and theoretical; applied research.
(*e*) The dynamics of ice jam formation and failure are being studied to get an indication of the maximum water level an ice jam can cause. Initially the investigation is concentrating on surges formed during ice jam formation and failure, and on the conditions for the formation of grounded ice jams and their characteristics.
(*g*) Initial analytical investigations have indicated that rapid and large increases in water level can be caused by surges formed during ice jam formation and failure. This is consistent with reports of such increases contained in historical records on ice breakup water levels.

402-11281-300-99

ICE SCARS AND ICE BREAKUP WATER LEVELS

(*b*) Boreal Institute for Northern Studies.
(*c*) Dr. R. Gerard.
(*d*) Field and analytical; applied research.
(*e*) A knowledge of ice breakup water levels is required for the design of river engineering structures and flood protection in cold regions. There are few measurements of these water levels, but a good record has been left in the ice scars on trees caused by high ice levels. The intent of this project is to evaluate the reliability of these ice scars as indicators of the maximum ice breakup water levels that have occurred and to determine how this water level 'record' can best be analyzed statistically.
(*g*) The investigation to date has shown that ice scars are a reliable indicator of past breakup water levels and that a meaningful statistical analysis is possible.

402-11282-300-90

DOCUMENTATION AND ANALYSIS OF ICE BREAKUP WATER LEVELS IN ALBERTA

(*b*) National Research Council of Canada.
(*c*) Dr. R. Gerard.
(*d*) Field and analytical; applied.
(*e*) Historical information on past breakup water levels at settled locations can be found from archives, resident interviews, etc. This type of information is being collected for selected sites in Alberta to allow an assessment of the probability distributions of these water levels and their magnitude relative to those caused by summer floods. As opportunity permits observations are also made of breakup at selected sites.
(*g*) A technique for analyzing this type of data has been developed and the records from one site on a large river have been analyzed. At this site ice breakup water levels are far more significant than those caused by summer floods.
(*h*) **Probability Analysis of Historical Flood Data,** R. Gerard, E. Karpuk, *J. Hydraulics Division, ASCE*, (in press).
Preliminary Observations of Spring Ice Jams in Alberta, R. Gerard, *Proc. 3rd Intl. Symp. Ice Problems, IAHR*, Hanover, N.H., U.S.A., pp. 261-277, 1975.

402-11283-210-00

VELOCITY DISTRIBUTION AND SECONDARY FLOW IN NONCIRCULAR CONDUITS

(*c*) Dr. R. Gerard.
(*d*) Theoretical and experimental; basic.
(*e*) Most conduits encountered in Civil Engineering are noncircular (rivers, canals). A knowledge of the velocity distribution in such conduits is required when assessing head losses, pollutant mixing, sediment transport and heat transfer. A finite element algorithm has been developed that shows some promise of giving reasonably good estimates of the velocity distribution (including secondary flows) but it has yet to be evaluated for a variety of conduit shapes and roughness. This is the intent of this investigation.
(*h*) **Turbulent Flow in Very Noncircular Conduits,** R. Gerard, W. D. Baines, *J. Hydraulics Division, ASCE* **103,** HY8, pp. 829-842, Aug. 1977.
Finite Element Solution for Flow in Noncircular Conduits, R. Gerard, *J. Hydraulics Division, ASCE* **100,** HY3, pp. 425-441, Mar. 1974.
Secondary Flow in Noncircular conduits, R. Gerard, *J. Hydraulics Division, ASCE* **104,** HY5, pp. 755-773, May 1978.

402-11284-370-96

ANALYSIS OF DYNAMIC ICE LOADS ON BRIDGE PIERS

(*b*) Alberta Cooperative Research Program in Transportation and Surface Water Engineering.
(*c*) Dr. R. Gerard.
(*d*) Analytical, applied.
(*e*) Field measurements of ice loads on bridge piers, collected under the above program, are being analyzed to determine simple expressions to allow the determination of effective ice pressures for bridge design.
(*g*) Results to date have indicated that a simple analysis is possible that gives results more in keeping with the field measurements than the Current Canadian Bridge Code recommendations. The reults have also pointed out the possible importance of the dynamic response characteristics of the pier.
(*h*) **Mode of Failure and the Analysis of Ice Loads on Bridge Piers,** R. Gerard, *4th Symp. Ice Problems, IAHR*, Lulea, Sweden, pp. 335-348, 1978

402-11285-810-96

LOW FLOWS IN NORTHEAST ALBERTA

(*b*) Alberta Oil Sands Environmental Research Program.
(*c*) Dr R. Gerard.
(*d*) Analytical, applied.
(*e*) Measurements of the low flows in northeastern Alberta are being analyzed using statistical techniques to determine the causes of the spatial and temporal variations of the low flows in this region.
(*g*) Records for most streams in the area cover a short period and this investigation is therefore only a prelimiary one. However, it has been shown that reasonable correlations exist between the low flows and the catchment characteristics; that the low flows on the larger streams have significant serial correlation, and that, at least for the one stream investigated in some detail, the low flow seems to respond to the precipitation of three years previous.

402-11286-810-00

MAXIMUM WATERSHED RESPONSE TO A MAXIMUM PRECIPITATION INPUT

(*c*) Dr. J. P. Verschuren.
(*d*) Theoretical, applied research, Doctoral thesis.
(*e*) Watershed parameters describing the state of the watershed are varied to obtain the largest possible peak discharge for a given input. The maximum probable precipitation will then be used to obtain the maximum probable peak discharge based on maximum response.
(*h*) **A Method to Determine Flood Hydrographs for Ungauged Watersheds,** M. Bristol, *M.Sc. Thesis*, Univ. of Alberta, 1975.
The Determination of Extreme Discharges for Gauged and Ungauged Watersheds in North Western Canada, J. P. Verschuren, *Proc. Canadian Hydrology Symp.:77*, 1977.

402-11287-810-00

AN ASSESSMENT OF INTERFLOW IN WATERSHED RESPONSE

(*c*) Dr. J. P. Verschuren.
(*d*) Theoretical, basic research, Doctoral thesis.
(*e*) A model of the interflow process was developed based on the concept that a flow impeding layer was present in the soil profile, causing formation of a saturated layer. Steep gradients then cause formation of interflow. A sensitivity study of the model parameters was conducted and the model was validated using data from a small mountainous watershed. The importance of interflow relative to other flow processes was assessed.

402-11288-810-90

FINITE ELEMENT ANALYSIS OF SUBSURFACE FLOW IN A WATERSHED

(*b*) Canadian Forestry Service.
(*c*) Dr. J. P. Verschuren, Professor of Civil Engineering.
(*d*) Theoretical, applied research, Doctoral thesis.
(*e*) Determine the changes in water yield from a forested area due to different logging practices using a distributed simulation model based on finite elements.

402-11289-810-96

AN ANALYSIS OF MAXIMUM PROBABLE PRECIPITIATION IN ALBERTA

(*b*) Alberta Environment.
(*c*) Dr. J. P. Verschuren.
(*d*) Theoretical, applied research, Doctoral thesis.
(*e*) All major storms that have occurred in Alberta are used to determine the regional pattern, the amounts of precipitation, extent of the storm and frequency of occurrence. The maximum probable precipitation will then be computed on a regional basis.

402-11290-300-90

CHANNELS FORMED IN SEDIMENT

(*b*) NRC of Canada.
(*c*) A. W. Peterson, Professor.
(*d*) Applied research.
(*e*) Modification of the mobile flow formula (Peterson, 1975, 1978 and Technical Notes 1977, 1978) to combine flume

results with the data for various phases of flow for sand and gravel rivers. The results of this study should aid in understanding the self adjustment of slope and depth in all types of natural mobile boundary channels.

402-11291-220-90

STUDY OF THE EFFECTS OF ABUTMENT GEOMETRY ON SCOUR IN ERODIBLE CHANNELS

(*b*) NRC of Canada.
(*c*) A. W. Peterson, Professor.
(*d*) Applied research.
(*e*) This project is in progress and should determine an improved relationship for clear water and dirty water scour at bridge abutments.

402-11292-300-90

RIP-RAP PROTECTION FOR MEANDERING CHANNELS

(*b*) NRC of Canada.
(*c*) A. W. Peterson, Professor.
(*d*) Applied research.
(*e*) This project is in its initial stages; the meander flume is being tested and calibrated. The project objective is to develop improved relationships for rip-rap design in river engineering applications such as bridge pier protection, bed and bank protection at bridge and pipeline crossings, and protection for river training works.

402-11293-300-90

COMPUTER SIMULATION OF DEGRADATION IN RIVERS

(*b*) NRC of Canada.
(*c*) A. W. Peterson, Professor.
(*d*) Applied research.
(*e*) Computer simulation of degradation in rivers.

402-11294-220-00

FLOW VISUALIZATION

(*c*) A. W. Peterson, Professor.
(*d*) Applied research.
(*e*) This project has been initiated to aid in the understanding of the mechanics of flows over mobile boundaries. A progress report (Karahan and Peterson, 1978) outlines the application of birefringents to flow visualization. Work is in progress using other visualization techniques.
(*h*) **The Visualization of Separation Zone on the Lee Side of Dune Shaped Bed Forms Using Streaming Birefringents,** M. E. Karahan, A. W. Peterson, *Rept. No. HY-1978-V1*, Dept. Civil Engrg., Univ. of Alberta, 1978.

402-11295-700-00

HYDRAULIC LABORATORY INSTRUMENTATION

(*c*) A. W. Peterson, Professor.
(*d*) Applied research.
(*e*) Development of a micro processor control system to aid in data collection for hydraulic model testing.
(*h*) **An Application of Microcomputers in the Control, Measurement and Analysis of Hydraulic Testing,** A. W. Peterson, B. A. Nwachukwu, R. G. Gitzel, *CSCE Specialty Conf.*, Toronto, May 1978.
The Bed Level Detector, A. W. Peterson, *Publ. No. HY-1978-E1*, Dept. of Civil Engrg., Univ. of Alberta, 1978.

402-11296-870-00

STORAGE OF RUNOFF–COMPUTER SIMULATION STORM WATER RUNOFF

(*c*) A. W. Peterson, Professor.
(*d*) Applied research.
(*e*) Computer simulation to study storage requirements for storm runoff.
(*h*) **Storage Requirements for Peak Runoff Control,** A. W. Peterson, P. H. Bouthillier, *Proc. Intl. Symp. Urban Storm Water Management*, Lexington, Ky., July 1978.

402-11297-700-90

LASER DOPPLER ANEMOMETER STUDIES

(*b*) NRC of Canada.
(*c*) A. W. Peterson, Professor.
(*d*) Applied research.
(*e*) The LDA provides an instantaneous velocity measurement at a very small point in space without interfering with the flow. The two systems presently available measure one and two components of the velocity vector, respectively. Currently the LDA is in the development stage, but it has been used to measure velocity profiles in a contained oil slick. Future projects include measurements in sand-water suspensions and flow characteristics of curved open channels.

402-11298-300-90

QUANTITATIVE FLUVIOLOGY

(*b*) University on NRC Grant.
(*c*) Dr. T. Blench.
(*d*) Basic and applied research.
(*e*) To aid the development of a formal quantitative inductive science of the self-adjustment of channels that form at least part of their boundaries in sediment. Steps are to collect and assess data; analyze and coordinate them in terms of an adequate "statement of case;" reduce the results to readily intelligible form, usually graphical; publicize the data, the results and their applications; and cooperate with other agencies.
(*h*) **Sediment Transport Formulas (Discussion),** *J. Hydraulics Division, Proc. ASCE* **98,** HY1, *Paper 8620*, pp. 284-289, Jan. 1972.
A Critical Review of Sediment Transport Experiments, R. H. Cooper, A. W. Peterson, T. Blench, *J. Hydraulics Division, Proc. ASCE* **98,** HY5, *Paper 8873*, pp. 827-843, May 1972.
Regime Problems of Rivers Formed in Sediment, T. Blench, Chapter 5 of *River Mechanics III*, Shen, Dept. of Civil Engrg., Colorado State Univ., 1973.
Comprehensive Graphs of Regime Data, T. Blench, A. W. Peterson, R. H. Cooper, *Research Symp. River Mechanics*, Bangkok, Thailand, Jan. 9-12, 1973.
General Report on River Bed Form, T. Blench, *ibid*, 1973.
Factors Controlling Size, Form and Slope of Stream Channels, T. Blench, *Proc. 9th Hydrology Symp., Natl. Res. Council*, May 1973, Queen's Printer, Ottawa, 1973.
Regime Data, Volume I, Flume Data and Regime Basics, T. Blench, D. B. Simons, Commissioned by Intl. Comm. on Irrigation and Drainage, 48th Nyaya Marg, Chankyapuri, New Delhi-21, India, 1974.
Graphic Coordination of Mobile-Bed Channel Data, T. Blench, R. H. Cooper, A. W. Peterson, *Hydrology Review*, Indian Natl. Comm. IHD/IHP, Council of Science and Industrial Research, Rafi Marq, New Delhi 1-110001, India, Oct. 1975.
Observations of Natural and Man-Made River Spurs, T. Blench, V. J. Galay, E. K. Yaremko, *3rd Ann. Symp. Waterways, Harbors and Coastal Engrg. Div., ASCE*, Aug. 10-12, 1976.

402-11299-220-90

EROSION BELOW CULVERTS

(*b*) NSERC of Canada and Alberta Department of Environment.
(*c*) N. Rajaratnam, Professor.
(*d*) Basic and experimental.
(*e*) To study erosion below culverts by treating the outflow from the culvert as a wall jet.
(*g*) The effect of tailwater depth and channel width has been studied. Report is under preparation.

402-11300-220-90

EROSION BY CIRCULAR WALL JETS IN CROSS-FLOW

(*b*) NSERC of Canada.
(*c*) N. Rajaratnam, Professor.
(*d*) Basic and experimental.
(*e*) To study erosion caused by circular wall jets discharged normal to the river flow, with relevance to diffuser designs for effluent disposal in rivers.

402-11301-300-90

HYDRAULICS OF CHANNELS WITH FLOOD-PLAINS

(*b*) NSERC of Canada.
(*c*) N. Rajaratnam, Professor.
(*d*) Basic and experimental.
(*e*) To predict the interaction between main channel and flood-plain flows and to develop a method to predict rating curves.
(*g*) Exploratory studies have been completed for straight and curved main channels with straight flood-plains.
(*h*) **Interaction Between Main Channel and Flood-Plain Flows,** N. Rajaratnam, R. Ahmadi, *Proc. ASCE, J. Hyd. Div.*, May 1979. A Doctoral Dissertation on the same subject by Mr. R. Ahmadi is being completed.

402-11302-300-90

GRAVEL RIVER MECHANICS

(*b*) NSERC, Canada; Alberta Department of the Environment; E.P.A., United States.
(*c*) Dr. Gary Parker.
(*d*) Experimental and field investigation; applied.
(*e*) Formulation of a resistance relation for gravel bars in order to expedite prediction of stream flow velocity and depth at below-flood stages at salmonid spawning grounds. Experimental scale model of an active braided gravel stream in order to study patterns of channel shifting and bar formation. Scour holes at anabranch confluneces are being studied to provide criteria for the design of pipeline crossings.
(*g*) Bar resistance in single-channel gravel streams is often negligible at stages high enough to activate the bed pavement. At progressively lower stages the bar, or pool-and-riffle, pattern begins to emerge and play a significant role in determining resistance. This has been described in terms of an empirical relation reminiscent of the Einstein-Barbarossa curve. Preliminary model studies suggest that natural braided gravel-bed streams can often be modeled adequately via Froude and geometric similarity in a laboratory flume containing sediment with a median size of 1 mm.

ATMOSPHERIC ENVIRONMENT SERVICE, Canadian Climate Centre, Hydrometeorology Division, CCAH, 4905 Dufferin Street, Downsview, Ontario, M3H 5T4, Canada. W. I. Pugsley, Division Chief.

403-11303-480-00

LAKE TO LAND COMPARISON OF WIND, TEMPERATURE AND HUMIDITY ON LAKE ONTARIO DURING THE INTERNATIONAL FIELD YEAR FOR THE GREAT LAKES (IFYGL)

(*c*) D. W. Phillips, Head, Developmental Climatological Systems Section–CCAS.
(*d*) Field investigation; applied research.
(*e*) The study was to re-evaluate earlier studies of differences of air temperature, humidity and wind data observed over land and over Lake Ontario. IFYGL archives of data from buoys and ships and data for land stations, the Atmospheric Environment Service and the National Weather Service were the principal sources of data.
(*f*) Completed.
(*g*) The results of this study are similar to those obtained by previous investigators but the values are less erratic and the standard deviations are smaller compared to earlier works. Testing of the findings on others of the Great Lakes appears to be warranted.
(*h*) **Lake to Land Comparison of Wind, Temperature and Humidity on Lake Ontario During IFYGL,** D. W. Phillips, J. G. Irbe, *Internal Atmospheric Environment Service Publ. CLI-2-77.*

403-11304-810-00

COMPUTER ENHANCED SNOW COVER ANALYSIS OF SATELLITE DATA

(*c*) W. D. Hogg, Head, Hydrometeorological Service-CCAH.
(*d*) Development and applied research.
(*e*) A semi-automated technique for using digital satellite data to map snow cover in a heavily forested area is described. The technique requires manual determination of a critical surface emission temperature separating snow covered and non-snow covered terrain using computer enhancement procedures and a colour graphics display. Once the critical temperature is identified, the digital infrared satellite data are analysed by a mini-computer to produce a snow cover map and estimates of snow cover areal extent for each sub-basin of interest. These values are used to update a hydrologic flow forecast model.
(*h*) **Computer Enhanced Snow Cover Analysis of Satellite Data,** W. D. Hogg, A. J. Hanssen, *Proc. Canadian Hydrology Symp. CHS:79, Cold Climate Hydrology*, 8 pages, May 1979. Paper available from author.

403-11305-810-00

SNOWCOVER MEASUREMENT

(*c*) Dr. B. E. Goodison, Mr. V. R. Turner, Dr. E. Langham.
(*d*) Field, applied, experimental.
(*e*) Studies on snow sampler and cutter re-design, standardization and metrication in North America; development of effective and accurate cutter for snow samplers; comparison of ground based methods of measuring snowpack water equivalent including portable gamma spectrometer; evaluation of SAR radar for discrimination of snowpack conditions; comparability of snowfall and snow course measurement.
(*h*) **Accuracy of Snow Samplers for Measuring Shallow Snowpack: An Update,** B. E. Goodison, *Proc. Eastern Snow Conf.* **35**, Hanover, New Hampshire (in press), 1978.
Comparability of Snowfall and Snow Cover in a Southern Ontario Basin, B. E. Goodison, *Proc. Modeling of Snow Cover Runoff, CRREL*, Hanover, N.H., Sept. 26-29, 1978 (in press).
Snowfall and Snow Cover in Southern Ontario, B. E. Goodison, *Ph.D. Thesis*, Univ. of Toronto, Toronto, Ontario, 403 pp., 1977.

403-11306-700-00

SNOWFALL MEASUREMENT IN CANADA

(*c*) Dr. B. E. Goodison, Mr. E. I. Mukammal, Mr. V. Turner, Mr. D. J. McKay.
(*d*) Field, applied, experimental.
(*e*) Studies of the accuracy of Canadian snow gauge measurements, comparisons with other national gauges, testing of artificial shielding of recording gauges, development of solid Nipher-type shields for recording gauges, development and testing of digital precipitation gauge wind tunnel experiments of flow around snow gauges.
(*h*) **Wind Tunnel Evaluation of Flow Around Snow Gauges,** V. R. Turner, presented *11th Ann. Canadian Meteorological Soc. Congress*, Winnipeg, Manitoba, June 1-3, 1977.
Canadian Snowfall Measurements: Some Implications for the Collection and Analysis of Data from Remote Stations, B. E. Goodison, D. J. McKay, *Proc. Western Snow Conf.* **45**, Otter Rock, Oreg., 48-57, Apr. 18-20, 1978.
Canadian Snow Gauge Measurements: Accuracy, Implications, Alternatives, Needs, B. E. Goodison, *Proc. 7th Symp.*

Applied Prairie Hydrology, Water Studies Institute, Saskatoon, pp. 7-15, May 9-11, 1978.

Accuracy of Canadian Snow Gauge Measurements, B. E. Goodison, *J. Applied Meteorology* **17**, 10, 1542-1548, 1978.

BEDFORD INSTITUTE OF OCEANOGRAPHY, Atlantic Oceanographic Laboratory, Dartmouth, Nova Scotia, B2Y 4A2, Canada. Director/General: Cedric R. Mann.

404–07852–460–00

AIR-SEA INTERACTION

(*c*) S. D. Smith, Air-Sea Interaction Group.
(*d*) Applied and basic research. Experimental and field investigation.
(*h*) Wind stress, heat exchange, evaporation and carbon dioxide exchange at sea surface by eddy correlation methods. Wave generation measurements using wave-following pressure and wind sensors. Participation in JASIN, POLYNYA Study (with IOS Patricia Bay).
(*h*) **Ocean Waves,** F. W. Dobson, *Ocean Sciences Reviews 1975/76*, Bedford Inst. of Oceanography, Dartmouth, N.S., Canada, pp. 3-14, 1977.

Eddy Fluxes of Momentum and Heat Measured Over the Atlantic Ocean in Gale Force Winds, S. D. Smith, *Turbulent Fluxes through the Sea Surface, Wave Dynamics, and Prediction*, Eds., A Favre, K. Hasselmann, pp. 35-50, Plenum, 1978.

Eddy Correlation Measurements of Sea-Air CO_2 Flux, E. P. Jones, S. D. Smith, *IBID*, pp. 137-150, Plenum, 1978.

Wave-Pressure Correlation Measurements Over Growing Sea Waves With a Wave Follower and Fixed-Height Pressure Sensors, F. W. Dobson, J. A. Elliott, *IBID*, pp. 421-432.

The Bight of Abaco Pressure Experiment, R. L. Snyder, R. B. Long, F. W. Dobson, J. A. Elliott, *IBID*, pp. 433-444.

A Comparison of the Air-Sea Interaction Flux Measurement Systems of the Bedford Institute of Oceanography and University of B.C., S. D. Smith, R. J. Anderson, E. G. Banke, E. P. Jones, S. Pond, W. Large, *Bedford Institute of Oceanography Internal Report BI-R-76-17*, 1976.

UNIVERSITY OF BRITISH COLUMBIA, Department of Civil Engineering, Hydraulics Laboratory, Vancouver, B.C., V6T 1W5, Canada. Dr. R. G. Campanella, Department Head.

405-10225-630-90

INFLUENCE OF WATER HAMMER ON TURBINE GOVERNING

(*b*) National Research Council of Canada.
(*c*) Dr. E. Ruus.
(*d*) Theoretical; applied research, Doctoral thesis.
(*e*) The influence of water hammer on turbine governing is considered at present by using rigid water column theory. This gives reasonably good results for relatively slow changes in turbine output, i.e., where the water hammer effect is small. The aim of this study is to incorporate the water hammer analysis according to the elastic water column theory into the turbine governing analysis, which would then yield satisfactory results even for rapid changes in output of turbines served by long penstocks.
(*f*) Completed.
(*g*) The elasticity of water and penstock wall increases the maximum deviation of the speed of the turbine. The main influence of the elasticity, however, appears in the reduction of stability, in particular at the high head power plants.

405-10229-810-96

EFFECT OF URBANIZATION ON STORM RUNOFF

(*b*) British Columbia Water Resources Service.
(*c*) Dr. S. O. Russell.
(*d*) Applied research.
(*e*) Urbanization affects the response of a basin to storm rainfall. Rainfall and runoff are being measured from two adjacent basins–one from the university complex which can be considered as urban, and one from an adjacent completely undeveloped basin.

405-10230-370-90

CULVERT DESIGN STUDY

(*b*) National Research Council.
(*c*) Dr. S. O. Russell.
(*d*) Applied research.
(*e*) Culvert design depends on many uncertain factors. Decision theory was used to determine an optimal design for a test case considering flow uncertainties, possible damage and culvert hydraulics.
(*f*) Completed.
(*g*) The design return period for major culters should be based on the local circumstances rather than on a blanket policy such as the 50 year flood. However, the expected total cost of a culvert is not too sensitive to the design flood return period.
(*h*) **Optimal Culvert Size Selection,** P. A. Neudorf, *M.A.Sc. Thesis*, Dept. of Civil Engineering, U.B.C. 1977.

405-10232-300-96

FLOOD PROBLEMS IN GRAVEL RIVERS

(*b*) B. C. Disaster Relief Fund.
(*c*) Dr. M. C. Quick.
(*d*) Applied research.
(*e*) Gravel rivers in flood frequently undergo drastic changes in their channel positions. Damaging flooding can result. The current research aim is to develop reasonable understanding of the necessary channel width and available sediment storage so that a gravel river can be kept stable within a predetermined channel.
(*g*) Sediment routing coupled with a hydrologic flow model has been developed.

405-10233-300-90

INTERACTION OF SEDIMENT AND RIVER FLOWS

(*c*) Dr. M. C. Quick.
(*d*) Applied research.
(*e*) Sediment bedforms and river channel cross-section and planform are studied as a sediment-flow interaction.
(*g*) Meandering processes have been modeled numerically using vorticity concepts. Bedforms are being studied analytically and experimentally, the emphasis being a basic sediment and flow processes.
(*h*) **Mechanics of Streamflow Meandering,** M. C. Quick, *J. Hydraulics Div., ASCE* **100,** HY6, pp. 741-753, June 1974.

405-10234-810-96

FLOOD FORECASTING

(*b*) British Columbia Disaster Relief Fund.
(*c*) Dr. M. C. Quick, Professor.
(*d*) Applied research.
(*e*) Two sets of computer models, a watershed model and a channel/reservoir routing model have been developed. The present emphasis concerns interpretation of local meteorological data in terms of basin wide behaviour for mountainous catchments. Snowmelt is a major contribution to these floods.
(*g*) An improved method of snowmelt calculation from temperature data has been developed. Orographic precipitation influences have been modeled using a stability factor based on adiabatic lapse rates.
(*h*) **Daily and Seasonal Forecasting with a Water Budget Model,** M. C. Quick, A. Pipes, *Proc. Intl. Symp. on the*

Role of Snow and Ice in Hydrology, UNESCO, WMO, and NRC, Canada, Banff, pp. 1017-1034, Sept. 1972.

Nonlinear Channel Routing by Computer, M. C. Quick, A. Pipes, *J. Hydraulics Div., ASCE* **101**, HY6, pp. 651-665, June 1975.

A Combined Snowmelt and Rainfall Runoff Model, M. C. Quick, A. Pipes, *Canadian J. Civil Engrg.* **3**, 3, pp. 449-460, Sept. 1976.

UBC Watershed Model, M. C. Quick, A. Pipes, *Hydrological Sciences Bulletin* **XXII**, 1, 3/1977.

UBC Watershed and Flow Manuals, M. C. Quick, A. Pipes, Dept. of Civil Engrg., UBC, 1976.

405-11315-210-90

A COMPARISON BETWEEN THE EQUAL-PERCENTAGE, THE UNIFORM, AND THE OPTIMUM CLOSURES OF A VALVE AT THE DOWNSTREAM END OF A SIMPLE PIPELINE

(*b*) National Research Council of Canada.
(*c*) Dr. E. Ruus.
(*d*) Theoretical; applied research.
(*e*) The required minimum time of closure, to keep the maximum pressure rise in the pipe within a prescribed limit is calculated. Closures from full and partial gate openings are considered. The required time of closure is plotted in terms of pipeline constant, pressure rise and pipe wall friction. Results of a valve closure according to an equal percentage law are compared with those resulting from uniform and optimum closures.
(*g*) Preliminary results show that a closure according to the equal percentage law requires a shorter time than that according to the uniform closure. This time is still substantially longer than that required by an optimum closure of the valve. Pipe wall friction has an appreciable influence on the required time of closure.

405-11316-810-90

USE OF GOES SATELLITE PHOTOGRAPHS FOR ESTIMATING PRECIPITATION

(*b*) National Research Council.
(*c*) Dr. S. O. Russell.
(*d*) Applied research.
(*g*) GOES imagery has been used for estimating rainfall from tropical convective storms. The procedure is being extended to frontal and convective storms over British Columbia for use in flood forecasting.

405-11317-210-90

PRESSURE RISE DUE TO WATER-COLUMN SEPARATION AND CLOSURE OF A CHECK VALVE FOLLOWING A TOTAL PUMP FAILURE

(*b*) National Research Council of Canada.
(*c*) Dr. E. Ruus.
(*d*) Theoretical; applied research.
(*e*) For a simple pump discharge line with a high point, maximum pressure rises due to the rejoining of the separated water columns and the closure of the check valves are calculated and plotted in nondimensional form. Pipeline constant, the inertia of the motor and the pump, pipe wall friction, as well as the location and elevation of the high point are considered, with a pump of specific speed equal to 7600 working under a rated head 40.0 feet.
(*g*) A large value of pipeline constant combined with a low pump inertia results in high pressure rise due to extensive water column separation at high points approaching the reservoir elevation.

THE UNIVERSITY OF CALGARY, Department of Mechanical Engineering, Calgary, Alberta, Canada T2N 1N4. P. G. Glockner, Department Head.

406-07319-740-90

NUMERICAL SOLUTION OF FLOW FIELDS

(*b*) National Research Council.
(*c*) Dr. D. H. Norrie.
(*d*) Theoretical; basic research.
(*e*) Develop finite element methods for flow fields of potential, viscous and other types. Current emphasis is on pulsating flow through dense matrix. Least square finite element application to convective and diffusive flows under consideration.
(*g*) Results have been obtained for potential, viscous, viscoplastic, and compressible flows, within specific ranges. Good agreement has been found with available data.
(*h*) **Finite Element Solution for Visco-Plastic Torsion,** G. de Vries, D. H. Norrie, *J. Strain Energy*, (in press) 1979.
Application of Pseudo-Functional Finite Element Method to Non-Linear Problems, D. H. Norrie, G. de Vries, Ch. 3, Vol. I, *Finite Elements in Flow Problems*, R. H. Gallagher, et al. (eds), John Wiley, pp. 56-65, 1975.
Recent Advances in Finite Element Methods Applied to Fluid Dynamics, D. H. Norrie, G. de Vries, Ch. 21 in Vol. 3, *Finite Elements in Flow Problems*, R. H. Gallagher, et al. (eds), John Wiley, 1978.

CANADA CENTRE FOR INLAND WATERS, National Water Research Institute, Hydraulics Research Division, P.O. Box 5050, Burlington, Ontario, L7R 4A6, Canada. T. M. Dick, Division Chief.

407-09509-200-00

TRANSVERSE DIFFUSION IN OPEN-CHANNEL FLOW

(*c*) Dr. Y. L. Lau.
(*d*) Experimental, basic research.
(*e*) Investigate the dependence of the diffusion coefficient on the different flow variables.
(*g*) The dependence of the dispersion coefficient on friction factor and width-depth ratio in rectangular channels has been investigated. Effect of a cross-section shape and variation of dispersion coefficient across the channel are being studied.
(*h*) **Transverse Dispersion in Rectangular Channels,** Y. L. Lau, B. G. Krishnappan, *J. Hyd. Div., ASCE*, HY10, Oct. 1977.
Transverse Dispersion in Trapezoidal Channels, Y. L. Lau, B. G. Krishnappan, *Proc. XVI Congress on Hydraulics and Hydraulic Constructions*, Torino, Italy, Sept. 1978.

407-09510-870-00

CRITERIA FOR OIL SLICK CONTAINMENT IN FLOWING WATER USING BOOMS

(*c*) Dr. Y. L. Lau.
(*d*) Experimental, applied research.
(*e*) Obtain criteria for oil spill containment and to produce realistic estimates of volume of oil containable under given flow conditions, conditions under which no containment is possible and feasibility of diverting oil slicks using booms under such conditions.
(*f*) Completed.
(*g*) Experiments were used to confirm the condition of no containment suggested by Wilkinson. In addition, a new criterion was discovered. Measurements of slick profiles enabled interfacial friction factors to be evaluated. Guidelines were established for the diversion of oil slicks as a function of boom angle and a densimetric Froude number.
(*h*) **Booms Used for Oil Slick Control,** Y.L. Lau, *J.Env. Eng. Div., ASCE*, Apr. 1979.

407-09512-870-00

ENERGY LOSSES AT SEWER PIPE JUNCTIONS

(*c*) Mr. J. Marsalek.
(*d*) Experimental; applied research.
(*e*) Energy losses at sewer pipe junctions are observed for various types of junctions.
(*g*) Experiments have been completed.
(*h*) A final report is under preparation.

407-09515-300-00

RESISTANCE OF BEAUHARNOIS CANAL UNDER WINTER CONDITIONS

(*c*) Dr. G. Tsang.
(*d*) Field, basic, applied.
(*e*) Study the Chezy c of Beauharnois Canal as season changes; try to relate the Chezy c with ice and other meteorological parameters.
(*f*) Scheduled to be completed in 1979.
(*g*) Eight years' data have been compiled and are being analyzed.

407-09517-390-00

FORMATION OF FRAZIL ICE IN WATER WITH SURFACE WAVES

(*c*) Dr. G. Tsang.
(*d*) Theoretical, basic.
(*e*) Study the heat flux and the formation of ice in water when subject to sinusoidal surface waves of various amplitude and frequency.
(*f*) Temporarily suspended.

407-10292-220-00

A HYDROGRAPHIC TECHNIQUE FOR BED LOAD DISCHARGE

(*b*) Water Survey of Canada.
(*c*) Mr. Peter Engel, Environmental Hydraulics Section, Hydraulics Research Division, National Water Research Institute.
(*d*) Experimental, theoretical, applied research, development.
(*e*) Theoretical development of a simple method to compute bed load transport rate from spatial and temporal survey of bed-form movement in large rivers.
(*h*) **Determination of Bed Load from Measurement of Dune Profiles–An Interim Report,** P. Engel, Hydraulics Research Division, NWRI. Unpublished report, 1977.
Estimation of Bed Load from Bottom Profiles, P. Engel, Hydraulics Research Division, NWRI. Unpublished report, 1978.
Modification to Hydrographic Method to Compute Bed Load from Dune Profiles in Open-Channel Flow, P. Engel, Y. L. Lau, Hydraulics Research Division, NWRI, *Technical Note 78-10*, 1978.
Preliminary Tests of the Hydrographic Method to Compute Bed Load Using Flume Data, P. Engel, Hydraulics Research Division, NWRI, *Technical Note 78-13*, 1978.
A Bed-Load Equation Using Average Departures About the Mean Bed Elevation and Dune Speed, P. Engel, Hydraulics Research Division, NWRI, *Technical Note 78-16*, 1978.

407-10296-300-00

MATHEMATICAL RIVER RESPONSE MODEL

(*c*) Dr. B. G. Krishnappan.
(*d*) Theoretical and field investigation; applied research.
(*e*) A mathematical model to predict hydraulic parameters of a stream for time-dependent flow rate and sediment input rate has been developed and is being tested for laboratory and field conditions.
(*g*) The laboratory testing has been completed and a favourable agreement between the model predictions and the laboratory measurements was obtained.
(*h*) **Mathematical Modeling of Flows in Natural Streams,** B. G. Krishnappan. Presented *4th Canadian Hydrotechnical Conference*, Vancouver, May 1979.
Mathematical Modeling of Sediment-Laden Flows In Natural Streams, B. G. Krishnappan, N. Snider, *Inland Waters Directorate, Scientific Series No. 81*, 1977.

407-10297-300-00

BASIC STUDY ON MEANDER FORMATION

(*c*) Dr. B. G. Krishnappan and Dr. T. M. Dick.
(*d*) Experimental; basic research.
(*e*) This study is undertaken to systematically conduct experiments and gather basic data which could shed some light on the basic mechanism of meander formation.
(*g*) Some modifications to the original experimental set up are being implemented.

407-10298-870-00

DEVELOPMENT OF AN ICE-OIL BOOM

(*c*) Dr. G. Tsang.
(*d*) Applied; development.
(*e*) Develop a boom to be used in ice infested, flowing waters. The purposes of the boom are: (a) deflecting drift ice floes to one side, (b) permitting oil to flow to the ice free area behind the boom through openings in the boom, and (c) deflecting the oil to the shore for recovery.
(*g*) A first generation boom has been developed and tested. The testing showed that the boom is very promising. Further laboratory experiments are being performed and a second-generation boom is being designed.
(*h*) Work so far is summarized in two papers:
An Ice-Oil Boom; From Tsang's Folly to Tsang's Boom, *Can. Research* **11**, p. 41, June 1978.
Development of a Novel Ice-Oil Boom For Flowing Waters, G. Tsang, N. Vanderkooy, *Proc. 1979 Oil Spill Conference*, Los Angeles, Mar. 1979.

407-10299-700-00

DEVELOPMENT OF A FRAZIL ICE INSTRUMENT

(*c*) Dr. G. Tsang.
(*d*) Development.
(*e*) To develop an instrument to measure point concentration of frazil ice.
(*g*) Based on the experimental instrument that was constructed and tested on the feasibility of the concept, a prototype instrument has been constructed and tested. Some electronic modifications are necessary to bring the instrument into operational state and this is presently being done.

407-10300-330-00

EFFECT OF SHIP PASSAGE ON UNCONSOLIDATED COVER

(*c*) Mr. R. Carson, Dr. G. Tsang.
(*d*) Applied.
(*e*) To study the effect of ship passage on the formation of ice jam in a fragmented ice cover.
(*f*) Completed.
(*g*) Laboratory experiments showed that the passage of a ship through an unconsolidated ice cover can cause an underwater ice dam to form; the criteria for such an ice dam initiation is very much affected by the condition of the ice cover; for a given ice cover, a ship moving downstream is more likely to produce an ice jam than one moving upstream; and both high and low ship speeds are not favourable for ice dam formation. Somewhere in between there is a ship speed range at which ice dams are most likely to form.
(*h*) **Effect of Ship Passage Through an Unconsolidated Ice Cover,** R. Carson, Hydraulics Research Division. Unpublished report, May 1978.

407-10302-870-99

RECOVERY OF SPILLED OIL IN RIVERS FROM CUT SLOTS IN THE ICE COVER

(*b*) Prairie Region Oil Spill Containment and Recovery Advisory Committee.

(*c*) Dr. E. C. Chen, Dr. G. Tsang, Mr R. Carson.
(*d*) Applied.
(*e*) To study the feasibility and the best way of recovering spilled oil from slots cut in the ice cover of rivers.
(*f*) Completed.
(*g*) The study showed that oil can be recovered from under river ice. A field experiment was carried out in Edmonton in the spring of 1978. The field experiment showed that 99 percent of the spilled oil was recovered. Besides cut slots on the ice cover, imbedded barriers and slot-barrier combinations were also studied. A new technology thus has been developed as a consequence of the study for recovering oil spilled under river ice cover.
(*h*) **Recovery of Oil Spilled Under River Ice Cover,** G. Tsang, *1979 Oil Spill Conference*, Los Angeles, Mar. 1979.

407-10304-300-90

ICE JAM FLOOD RISK MAPPING

(*b*) Atlantic Region, Inland Waters Directorate, Department of Fisheries and the Environment.
(*c*) Mr. R. Carson.
(*d*) Applied.
(*e*) To map the sites of probable flooding due to ice jamming in the Salmon River, Nova Scotia.
(*f*) Completed.
(*g*) Probable flood levels were estimated based on historical flood records available.
(*h*) **Effect of Ice Jams on Flooding in Truro, N.S.,** R. Carson, Hydraulics Research Division. Unpublished report, 1978.

407-11307-700-00

PERFORMANCE OF THE PRICE CURRENT METER

(*c*) Mr. Peter Engle, Environmental Hydraulics Section, Hydraulics Research Division, National Water Research Institute.
(*d*) Experimental; applied research.
(*e*) Tests conducted in a towing tank to evaluate the effect of seven independent variables on the rate of rotation of the meter. The results will provide information on the behaviour of the meter applicable to a wide range of field conditions likely to be encountered.
(*g*) An outline of experiments was prepared to implement a detailed study of the performance of the Price current meter. Through dimensional analysis, together with examination of available literature, seven dimensionless independent variables have been identified for study, resulting in a total of seven experiments. In the first experiment, criteria to determine the waiting time between successive tows in a towing tank were established. A Price meter with standard suspension was towed and the waiting times varied. The study showed that disturbance of the water prior to a calibration run does not affect the minimum waiting time significantly. For the Price meter, the waiting time varies inversely as the square root of the towing speed. In the second experiment, the performance of the Price meter when placed at a horizontal angle to the direction of flow was investigated. Tests were conducted to study the performance of the Price 622AA current meter when placed at a horizontal angle to the direction of flow. Results indicate that the behaviour of the meter is unsymmetrical for misalignment to the left and the right. In this respect, the Price meter should not be allowed to deviate from true alignment with the flow by more than 10° to the left and 15° to the right so as not to exceed errors due to alignment by one percent. The effect of the tail fin in increasing errors is insignificant for misaligned meters and can be neglected for practical purposes.
(*h*) **An Experimental Outline to Study the Performance of the Price Current Meter,** P. Engel, Hydraulics Research Division, NWRI. Unpublished report, 1977.
Determination of Waiting Times Between Successive Runs when Calibrating Price 622AA Type Current Meters in a Towing Tank, P. Engel, C. DeZeeuw, Hydraulics Research Division, NWRI. *Technical Note No. 77-17*, 1977.
The Effect of Horizontal Alignment on the Performance of Price 622AA Current Meter, P. Engel, C. DeZeeuw, Hydraulics Research Division, NWRI. Unpublished report, 1978.

407-11308-200-00

TURBULENCE MODEL FOR MASS TRANSFER IN OPEN CHANNELS

(*d*) Theoretical; experimental; applied research.
(*e*) To establish a numerical model for mass transfer in open-channel flows using a model to describe the turbulence properties.

407-11309-300-00

MODELING DISPERSION IN ICE-COVERED RIVERS

(*c*) Dr. Y. L. Lau.
(*d*) Theoretical; experimental applied research.
(*e*) To investigate the effect of ice covers on dispersion in rivers using a turbulence model.

407-11310-300-00

BOTTOM ROUGHNESS IN ALLUVIAL CHANNELS

(*c*) Mr. Peter Engel, Environmental Hydraulics Section, Hydraulics Research Division, National Water Research Institute.
(*d*) Experimental, basic research.
(*e*) Experiments were conducted to measure the total friction factor as a function of artificial bed-form geometry, grain size and flow conditions. Results are compared with data from literature and some observations are made regarding present practices of computing friction factors when dunes form on the mobile stream bed.
(*h*) **Friction Factor for Flow over Duned Beds,** P. Engel, Y. L. Lau, Hydraulics Research Division, NWRI Proceedings, *Transport Processes and River Modeling Workshop*, Nov. 20 and 21, 1978, NWRI, Canada Centre for Inland Waters, Burlington, Ont.

407-11311-370-90

ROAD DRAINAGE INLET CAPACITY

(*b*) Ministry of Transportation and Communications.
(*c*) Mr. J. Marsalek.
(*d*) Experimental; applied research.
(*e*) Prototypes of selected inlet structures were tested in the laboratory. Inlet capacities were measured for various pavement spreads, grades, and crossfalls.
(*h*) A progress report is under review.

407-11312-470-90

COBOURG HARBOUR MODEL STUDY

(*b*) Small Craft Harbours Branch, Department of Fisheries and Oceans (Canada).
(*c*) Dr. M. G. Skafel.
(*d*) Experimental; design.
(*e*) A 1:72 scale model of Cobourg Harbour, Lake Ontario is being used to evaluate different schemes to reduce wave agitation inside the harbour.

407-11313-410-00

LITTORAL DRIFT AND EROSION MODEL

(*c*) Dr. M. G. Skafel and Mr. J. P. Coakley.
(*d*) Field investigation; applied research.
(*e*) Waves, currents and sediment transport are being measured on a sand beach to provide data for modeling sediment transport in the littoral zone.

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CONCORDIA UNIVERSITY, Department of Civil Engineering, Montreal, Quebec H3G 1M8, Canada. A. S. Ramamurthy.

408-11318-700-90

LATERAL WEIR FLOW MODEL

(*b*) National Research Council.
(*c*) A. S. Ramamurthy.
(*d*) Experimental and theoretical; Doctoral dissertation (completed).
(*e*) The hydrodynamic theory of flow through a lateral conduit outlet was used to develop the Lateral weir flow model. Experiments were conducted to verify the theoretical predictions.
(*f*) Completed.
(*h*) *D.Eng. Thesis*, 1978.

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DALHOUSIE UNIVERSITY, Institute of Oceanography, Halifax, Nova Scotia, Canada B3H 4J1. Dr. Peter J. Wangersky, Director.

409-09518-420-00

SURF ZONE AND NEARSHORE HYDRODYNAMICS

(*c*) A. J. Bowen and D. A. Huntley.
(*d*) Theoretical and field experimental; basic research.
(*e*) Develop theories of nearshore wave/motion and steady currents, and test theories by field experiments. Investigation of surf beat, edge waves and turbulent stresses on bottom sediment.
(*g*) See papers.
(*h*) **Simple Models of Nearshore Sedimentation: Beach Profiles and Offshore Bars,** A. J. Bowen, *Proc. Conf. on Coastlines of Canada, Halifax, 1978*, Geological Survey of Canada (in press).
Edge Waves and Surf Beat, A. J. Bowen, R. T. Guza, *J. Geophys. Res.* **83,** 1913-1920, 1978.
Infragravity Waves in Storm Conditions, R. A. Holman, D. A. Huntley, A. J. Bowen, *Proc. 16th Coastal Engrg. Conf.*, Hamburg. New York: American Society of Civil Engineers (in press).
Edge Waves on a Crescentic Bar System, D. A. Huntley, *Proc. Conf. on Coastlines of Halifax, 1978*, Geological Survey of Canada (in press).
Beach Cusps and Edge Waves, D. A. Huntley, A. J. Bowen, *Proc. 16th Coastal Engrg. Conf.*, Hamburg. New York: American Society of Civil Engineers (in press).
Velocity and Stress Measurements in a Tidal Inlet, D. A. Huntley, D. Nummedal, *Proc. 16th Coastal Engrg. Conf.*, Hamburg. New York: American Society of Civil Engineers (in press).

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ENVIRONMENT CANADA, National Hydrology Research Institute, 10th Floor, Place Vincent Massey, Ottawa K1A OE7, Ontario, Canada.

411-11314-810-00

CLIMATOLOGICAL ESTIMATES OF AREAL EVAPOTRANSPIRATION AND LAKE EVAPORATION

(*c*) F. I. Morton, Research Scientist.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) The project involves progressive development of computer models to estimate areal evapotranspiration and lake evaporation from routine observations of temperature, humidity and sunshine duration anywhere in the world with no need for locally optimized coefficients. Both the areal evapotranspiration and lake evaporation models are based on the concept of a complementary relationship between actual and potential evaporation. This concept permits the areal evapotranspiration to be estimated from its effects on the temperature and humidity of the overpassing air (as reflected in the potential evaporation estimates) thereby avoiding the complexities of the soil-plant system; and permits the lake evaporation to be estimated from observations made in the land environment by taking into account the modification of the air as it passes from the land over the lake. As in all modeling exercises the basic concept must be associated with other assumptions and poorly defined empiricisms. However the lack of locally optimized coefficients permits the detection and correction of erroneous assumptions and relationships by progressive testing over an ever-widening range of environments.
(*g*) The most recent version of the areal evaporation model has been tested by comparing the model estimates averaged over periods of 5 years or more with the corresponding water budget estimates for 122 river basins in Canada, Ireland, Kenya and the southern United States. The most recent version of the lake evaporation model has been tested by comparing annual model estimates with the corresponding water budget estimates for seven lakes representative of widely differing environments in Canada and the United States.
(*h*) **Estimating Evapotranspiration from Potential Evaporation: Practicality of an Iconoclastic Approach,** F. I. Morton, *J. Hydrology* **38,** pp. 1-32, July 1978.
Climatological Estimates of Lake Evaporation, F. I. Morton, *Water Resources Research* **15,** 1, pp. 64-76, Feb. 1979.

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GOVERNMENT OF CANADA, Department of Fisheries and Oceans, Institute of Ocean Sciences, Patricia Bay; Ocean and Aquatic Sciences, Pacific Region, 9860 West Saanich Road, Sidney, B.C. Canada, V8L 4B2. R. W. Stewart, Director-General.

412-11319-060-00

SALT WEDGE IN LOWER FRASER RIVER

(*c*) Mr. A. B. Ages.
(*d*) Theoretical and field investigation; applied research.
(*e*) Hydrodynamics of the salt wedge in the Fraser River based on extensive ongoing field program.

412-11320-870-00

OIL SPILL PREDICTION

(*c*) Mr. A. B. Ages.
(*d*) Field investigation; applied research.
(*e*) Field evaluation of oil spill model based on surface wind velocities, tidal currents and spreading velocities.

412-11321-300-00

NUMERICAL MODEL OF FRASER RIVER PLUME IN STRAIT OF GEORGIA, B.C.

(*c*) Dr. P. B. Crean.
(*d*) Theoretical and field investigation; applied research.
(*e*) Boundary information from an earlier large-scale barotropic model is being used to provide tidal forces and interface stresses for a buoyant, spreading upper layer model of the Fraser River discharge.

412-11322-410-00

NUMERICAL AND HYDRAULIC MODELING OF TIDAL FLOW OVER SILLS

(*c*) Dr. D. Farmer, Dr. T. S. Murty.
(*d*) Theoretical, laboratory and field investigation; applied research.
(*e*) Numerical and hydraulic models are being used to investigate non-linear hydraulic jumps and consequent mixing in stratified flow over sills in coastal inlets.

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LASALLE HYDRAULIC LABORATORY LTD., 0250 St. Patrick Street, Lasalle, Quebec, Canada H8R 1R8. F. E. Parkinson, Eng., Vice President.

413-09548-870-90

INFLUENCE OF THE SUBMERGENCE OF A HYDROFOIL DEFLECTOR ON ITS EFFICIENCY

(*b*) Canadian Coast Guard, Department of Transport.
(*d*) Experimental, applied research.
(*e*) As part of a general study on the use of deflectors for the diversion of accidental oil spills, determination of the overall efficiency with respect to the hydraulic draft. Study carried out on a laboratory testing channel.
(*f*) Completed.
(*g*) Report submitted to the Canadian Coast Guard. It was possible to relate numerically the efficiency and the submergence.

413-10251-350-73

EASTMAIN SPILLWAY–JAMES BAY PROJECT

(*b*) James Bay Energy Corporation; Lalonde, Girouard, Letendre, and Associates, Consulting Engineers, Montreal.
(*d*) Experimental; design.
(*e*) Study on a 1/100 scale model of a spillway located in a diversion canal and designed to carry a peak outflow of 211,000 cfs with a maximum head of 65 feet. Special attention was given to potential scouring of the riverbank and to flow conditions during winter.
(*f*) Completed.

413-10257-350-73

CANIAPISCAU DIVERSION TUNNEL AND SPILLWAY–JAMES BAY PROJECT

(*b*) James Bay Energy Corporation; Lemieux, Monti, Nadon, Roy, Inc., Consulting Engineers, Montreal.
(*d*) Experimental; design.
(*e*) A 1/100 scale model including a spillway and its tailrace canal (peak flow 130,000 cfs) and a diversion tunnel (peak flow 110,000 cfs). The main characteristic of the project is the superimposed arrangement of the spillway and canal on top of the diversion tunnel with the tailrace canal of the tunnel serving as a dissipating basin for the spillway flow. The model was used to investigate flow conditions mainly in the tailrace canal of the diversion tunnel and in the intake canal of the spillway. Calibration of both structures was made and flow conditions during winter with ice were examined.
(*f*) Completed.

413-10258-350-73

EASTMAIN, OPINACA, LA GRANDE (E.O.L.) CONTROL STRUCTURE–JAMES BAY PROJECT

(*b*) James Bay Energy Corporation; Lalonde, Girouard, Letendre and Associates, Consulting Engineers, Montreal.
(*d*) Experimental; design.
(*e*) A 1/100 scale model study of a three-gated control structure designed for a peak flow of 70,000 cfs. The study includes the investigation of various flow conditions and calibration of the structure. Excavation in the downstream reach as required by winter ice flow conditions was also being studied.
(*f*) Completed.

413-10260-520-90

MOORING FORCES OF LARGE VESSELS BERTHED AT OFFSHORE TERMINALS

(*b*) Canadian coast Guard, Department of Transports.
(*d*) Experimental, applied research.
(*e*) On a 1/100 scale model duplicating the Come-by-Chance terminal conditions, VLCC models, the largest being 412,000 DWT, were used to study the dynamics of mooring line forces generated as a result of combinations of wave conditions, lines-pretensioning, line-elongation characteristics, nylon-tail addition to steel lines, vessel loading, and mooring arrangements. With the view of developing practical guidelines for the general user, the program was expanded in a later phase to environmental conditions beyond those expected at the site of Come-by-Chance terminal.
(*f*) Completed.
(*g*) Final report submitted to the Canadian Coast Guard.

413-10265-340-73

LIMESTONE GENERATING STATION

(*b*) Manitoba Hydro through Crippen Acres Engineering, Consultants.
(*d*) Experimental design.
(*e*) 1/500 horizontal and 1/150 vertical scale ice model studies. The Limestone Generating Station is to be built in a reach of the Nelson River subject to severe ice jamming. During the winter, under existing conditions the staging of the ice cover causes a rise in water level of about 15 meters above the open water conditions. The object of the model study was to determine winter water levels and stability of the ice cover under different diversion conditions.
(*f*) Completed.
(*g*) Ice and water levels were defined for fully developed winter staging conditions with modified river flows caused by upstream powerhouse operations. Two stages of cofferdam construction were considered, and the past two winters have given valid confirmation of the model predictions.

413-10270-350-87

SIDI SAAD DAM

(*b*) Ministry of Development, Tunisia, SNC, Consultants.
(*d*) Experimental design.
(*e*) 1/100 scale model study of hydraulic design of the spillway and energy dissipation downstream.
(*f*) Completed.
(*g*) An economical spillway arrangement using two stages was developed. The first stage was a trajectory bucket discharging into a concrete lined stilling basin, and the second stage was an aerated weir spilling into a gabion protected channel downstream.

413-11654-340-73

FORKED RIVER NUCLEAR PLANT

(*b*) Jersey Central Light and Power Co.–Burns and Roe, Consultants.
(*d*) Analytical, mathematical model study.
(*e*) Brief theoretical study to assess the likelihood of ice jam conditions occurring at the service water intake.

413-11655-340-73

HOPE CREEK GENERATING PLANT

(*b*) Public Services Electric and Gas Co.–Bechtel, Consultants.
(*d*) Experimental, design.
(*e*) A 1/5 scale model was used to study flow supply conditions to the service water pumps. Eight pumps will be provided in each intake, and sluices between bays will allow supply to pumps from the adjacent bays. A sparger system was provided to re-suspend silt so it will go through the pumps.
(*f*) Report in preparation.
(*g*) A modification to the sumps in the form of a perforated screen wall was developed to ensure proper flow to the pumps; i.e., elimination of vortices. Detailed changes to the sparger system nozzle layout, number and discharge were made to improve sediment removal characteristics.

413-11656-340-73

RIO VINTO ESTE INTAKE

(*b*) Bolivian National Electricity Authority–Montreal Engineering Co. Ltd.–Consultant.
(*d*) Experimental, design.

(*e*) Expansion of the Santa Isabella Plant will include construction of an additional water intake on the Rio Vinto Este. The model at scale 1/12 was built at the San Andreas University, La Paz, to study sediment excluder concepts for this intake.
(*f*) Completed.
(*g*) Consulting services provided to complete testing program by developing modified intake structures that effectively removed the sand and gravel.

413-11657-350-87

MADA RIVER MULTIPURPOSE DEVELOPMENT

(*b*) Lower Benue River Development Authority–Nigeria–ShawMont Nigeria Ltd.
(*d*) Experimental, design.
(*e*) The dam to be built at Tede for flood control and as an irrigation reservoir also includes a powerhouse and cascade spillway excavated into the left abutment. A comprehensive model at 1/100 scale was used to study operations of the spillway and powerhouse as well as the single stage diversion arrangement.
(*f*) Completed.
(*g*) Modifications were developed for the downstream permanent cofferdam layout to eliminate deposition of material in the tailrace channel, as well as for the diversion channel control section to improve discharge capacity. Minor changes were required in the power intake tower to eliminate vortices. The cascade spillway as designed worked very efficiently.

413-11658-340-87

LA VOHITRA HYDROELECTRIC DEVELOPMENT

(*b*) Madagascar National Electricity Authority–Montreal Engineering Co. Ltd–Consultants.
(*d*) Experimental, design.
(*e*) Development of the Grand Rogez site will include construction of a diversion weir and water intake to supply the powerhouse. Problems were mainly associated with heavy sediment transport by the stream. A 1/50 scale model, using both sand and sawdust to simulate sediment, was used to study the structures. A separate study at scale 1/20 was carried out to develop a sand trap in the power tunnel.
(*f*) Completed.
(*g*) Weir, intake and spillway gate modifications were developed to exclude most of the sediment. Part of the river valley was used as a natural sediment trap.

413-11659-340-87

KENERING HYDROELECTRIC DEVELOPMENT

(*b*) National Electricity Board, States of Malaya–Shawinigan Engineering Co. Ltd.–Consultants.
(*d*) Experimental, design.
(*e*) A comprehensive model at 1/100 scale was used to study the construction phases during diversion, as well as the spillway and powerhouse operation.
(*f*) Completed.
(*g*) A raised level trajectory bucket spillway was developed which provided acceptable scour and deposit characteristics downstream. There may still remain some problems with tailwater levels if maximum floods occur, but it was not judged advantageous to provide remedial works. Corrective dredging could be necessary in such cases. The power intakes were modified to eliminate vortices. Modifications to the spillway gate operating procedures were recommended to protect the cofferdams during diversion.

413-11660-340-87

BERSIA HYDROELECTRIC DEVELOPMENT

(*b*) National Electricity Board, State of Malaya–Shawinigan Engineering Co. Ltd.–Consultant.
(*d*) Experimental, design.
(*e*) A 1/100 scale comprehensive model was used to study the spillway and powerhouse operation as well as the three stages of diversion.
(*f*) Completed.
(*g*) With the original design scour and subsequent deposit downstream of the spillway seriously encroached on tailrace flow from the powerhouse. A shorter spillway structure was developed with efficient trajectory buckets that controlled the scour and deposit. Modifications to the upstream face of the dam eliminated vortices above the power intakes. Cofferdam alignments were modified, and gate operating procedures specified during diversion tests in order to avoid scour of the left bank or timber crib structures.

413-11661-340-73

HOPE CREEK NUCLEAR GENERATING STATION

(*b*) Public Services Electric and Gas Co.
(*d*) Analytical, mathematical model study.
(*e*) Using potential ice generation values resulting from the parallel study at Salem Plant, calculations were carried out to define the possibility of ice jams' forming at the service water intakes.
(*f*) Completed.
(*g*) An ice jam is possible, so modifications to the proposed hot water recirculating system were suggested.

413-11662-340-73

SALEM NUCLEAR GENERATING PLANT

(*b*) Public Services Electric and Gas Co.
(*d*) Analytical, mathematical model study.
(*e*) Theoretical analysis of ice generation potential in the Delaware River, and its possible accumulation at the cooling water intake.
(*f*) Completed.
(*g*) Under extreme meteorological conditions which have already been experienced at the plant site, the formation of a significant ice jam is possible. Corrective measures in the form of ice booms and hot water injections were recommended.

413-11663-870-36

SWIRL CONCENTRATOR AS STORMWATER REGULATOR

(*b*) American Public Works Association as research agent for the Environmental Protection Agency.
(*d*) Experimental, research and development.
(*e*) Earlier development studies had been done on a 1/12 scale model. The present tests were done on a 1/6 scale model, giving the opportunity to check sediment recovery scale-up principles, and to extend the range of structure shapes.
(*f*) In progress.
(*g*) Some inconsistency in the sediment scale-up procedure seems apparent. Additional testing has provided the new relations necessary so field predictions should be more accurate. Field testing of a pilot installation at Lancaster, Pennsylvania, is being monitored for further comparisons.

413-11664-340-73

SURRY NUCLEAR GENERATING STATION-UNITS 1 AND 2

(*b*) Virginia Electric Power Co.
(*d*) Experimental, design.
(*e*) 1/2 scale model used to study recirculation spray pumps for both units that were installed in deep cylindrical casings. Excess bottom clearance and asymmetric supply to the casing combined to form strong bottom vortices.
(*f*) Completed.
(*g*) Flow control assemblies to be fixed onto the pump bellmouths were developed. They consisted of a combined skirt and cross-vane arrangement, that effectively imporved the flow, at the same time as significantly reducing headlosses in the casing.
(*h*) Report submitted to Vepco.

413-11665-340-73

BEAVER VALLEY NUCLEAR PLANT–UNIT 1

(*b*) Duquesne Light Co.–Ingersoll-Rand Pump Co.–Supplier.
(*d*) Experimental, design.
(*e*) 1/2 scale model used to study casing installation of low head injection pumps. Bottom vortexing and pre-rotation were identified as problem sources.
(*f*) Completed.
(*g*) A manifold flow distributor incorporating turning vanes was developed and recommended.
(*h*) Report submitted to Duquesne.

413-11666-340-73

NORTH ANNA NUCLEAR PLANT–UNITS 3 AND 4

(*b*) Virginia Electric Power Company–Gingham–Willamette Pump Co.–Supplier.
(*d*) Experimental, design.
(*e*) 1/2 scale model to study layout of recirculation spray pumps in a restricted casing. Bottom vortices were found that would impair pump performance.
(*f*) Completed.
(*g*) First phase studies developed a combination skirt and cross-vane assembly to be fixed under the pump bellmouth. It corrected the flow well, but had restricted clearance tolerances. The manufacturer did full scale pilot tests, proving with uncanny precision the tolerance requirements predicted on the model. Their suggested modified split under-plate was later tested and found to be satisfactory.
(*h*) Report in preparation.

413-11667-340-73

NORTH ANNA NUCLEAR PLANT–UNIT 1

(*b*) Virginia Electric Power Company–Ingersoll–Rand Pump Co.–Supplier.
(*d*) Experimental, design modification.
(*e*) 1/2 scale model used to study casing enclosed recirculation spray pumps which had not performed as required in preliminary field tests. Severe vortexing of the bottom of the casing was found to be the problem. Later tests were also carried out on the low head injection pumps.
(*f*) Completed.
(*g*) A manifold flow distributor incorporating turning vanes was developed on the model for the recirculating pumps. Subsequent installation in the plant, and testing over 600 hours of continuous operation confirmed the model predictions. The low head safety injection pumps, in a slightly different casing arrangement, were found to be acceptable.

413-11668-340-73

WANSLEY GENERATING STATION

(*b*) Georgia Power Co.–Southern Services Ltd.–Consultants, Ingersoll–Rand Pump Co., Suppliers.
(*d*) Experimental, operations improvement.
(*e*) 180,000 gpm circulating water pumps were not performing as required, and the curved supply tunnels to the sumps were suspected as being responsible. A 1/10 scale model was used to check the flow characteristics and to develop remedial works.
(*f*) Completed.
(*g*) Multiple vortex centres were eliminated by installing a mask wall with an oval opening in front of the bellmouth.
(*h*) Recommended modifications and report submitted to Georgia Power.

413-11669-300-73

BURNTWOOD RIVER AT THOMPSON, MANITOBA

(*b*) Manitoba Hydro.
(*d*) Analytical, mathematical model study.
(*e*) Diversion of Churchill River water into the Nelson River through the Burntwood will raise its winter discharges significantly. Studies were carried out to define the ice cover formation mechanics near the town of Thompson to ensure safety of its water supply intake and winter recreational activities on the ice.
(*f*) Completed.
(*g*) Water levels were just acceptable for continued operation of the water supply pumphouse. Rough cover surface and internal instability would make recreation on the stretch of river in front of the town unsafe, so an alternate area was suggested.

413-11670-340-87

DADIN KAWA DAM

(*b*) Upper Benue river Development Authority–Nigeria–ShawMont Nigeria Ltd.–consultants.
(*d*) Experimental, design.
(*e*) 1/50 scale comprehensive model of dam, spillway and powerhouse. The prime concern was development of a spillway with adequate energy dissipating ability so its scour and deposits would not hinder powerhouse operations. A tenacious vortex over the power intake required considerable study.
(*f*) Completed.
(*g*) A simple, efficient trajectory bucket spillway was developed, along with a pre-excavated plunge pool. A large deflector wall in the reservoir was found necessary to eliminate the power intake vortex.
(*h*) Report submitted to ShawMont.

413-11671-330-87

JEBBA NAVIGATION LOCK

(*b*) National Electric Power Authority–Nigeria–Montreal Engineering Co. Ltd.–Consultants.
(*d*) Experimental, design.
(*e*) 1/25 scale model study of 30 meter lift lock with chamber dimensions of 12.2 × 200 meters. Combination of analytical and physical model studies used to develop chamber filling and emptying system.
(*f*) Completed.
(*g*) A bottom culvert with perforated slab distribution system was devloped which allows smooth filling and emptying operations in under 15 minutes.
(*h*) Report submitted to MECO.

413-11672-340-73

LG-4 POWER INTAKE

(*b*) James Bay Energy Corporation and Rousseau, Sauvē, Warren, Inc.–Consulting Engineers.
(*d*) Model investigation; design.
(*e*) 1/80 scale model of forebay and intakes. Even with practically ideal approach flow conditions and a suitable intake designing (LG4 intake format is similar to the intakes for LG2 and LG3, which were extensively model tested), satisfactory inflow conditions free from vortices or other disturbances were obtained only after the following alterations had been made: a) complete closure of the flow passage left between the individual intakes in the original design; b) addition of a streamline-shaped wall at each of the two extreme intakes, with extra width given to the intake canal to account for the two above end walls.
(*f*) Completed.

413-11673-060-73

LA GRANDE ESTUARY (SALT WATER INTRUSION STUDY)

(*b*) James Bay Energy Corporation and Vézina, Fortier and Associates, Consulting Engineers.
(*d*) Model investigation, applied research.
(*e*) The study was conducted on the existing estuary model which reproduced to linear scales of 1:600 horizontally and 1:150 vertically a portion of James Bay and the La Grande River to the head of tide, at mile 21. The model was first operated to establish the salinity regime for existing conditions, and then to establish the regime following closure of the LG2 diversion tunnels, when the reservoir started being filled. As a practical result, closure time was

delayed from October to December 1978 until the ice cover had formed (the tests having shown that the ice cover would maintain salt intrusion below mile 12, as opposed to clear water tests in which the entire estuary was contaminated).
(*f*) Completed.
(*g*) Field operation in the winter of 1978-79 confirmed the model predictions.

413-11674-870-70

BAYWAY REFINERY SECONDARY WATER TREATMENT FACILITY (MODEL TESTING RECYCLE SLUDGE PUMPING STATION)

(*b*) Exxon Company, U.S.A.
(*d*) Model investigation; design.
(*e*) A 1/6 scale model was used to ensure uniform and vortex-free approach flows to the pumps.
(*f*) Completed.

413-11675-870-70

BAYWAY REFINERY (MODEL TESTING OF THE FILTER FEED SUMP FOR THE POST-BIOX FILTRATION PROJECT)

(*b*) Exxon Company, U.S.A. and Williams Brothers Process Services, Inc., Consultants.
(*d*) Model investigation; design.
(*e*) The arrangement was studied on a 1/6 scale model. Detailed modifications were developed inside the sump to ensure uniform water supply to each pump.
(*f*) Completed.

413-11676-340-73

INDIAN RIVER STATION–UNIT 4 (INTAKE SUMP MODEL TESTS)

(*b*) Delmarva Power and Light Co., U.S.A.; Ingersoll-Rand Co. (Cameron Pump Division); Gilbert/Commonwealth Engineers and Consultants.
(*e*) The 1/10 scale model reproduced a section of the cooling tower basin and the intake sump (the forebay, the inlet channels and the pumps). Pump approach flows were evaluated with the proposed intake design, which needed no modification.
(*f*) Completed.

413-11677-350-73

SUBMERGED INTAKE AND ROCK PLUG BLAST, ADDITIONAL POWER, MANIC-5

(*b*) Hydro-Québec and ABBDL, Consultants.
(*d*) Model investigation; design.
(*e*) The 1/60 hydraulic model reproduces a portion of the upstream reservoir and Daniel Johnson Dam; the inlet, sump and air shaft arrangement; the intake tunnel and structure; a portion of the supply tunnel. Main objectives of the investigation are: a) to determine the shape and size of the sump required to catch the rock from the plug when it is blasted; b) to evaluate the hydraulic functioning of the intake design as a whole, so that intake conditions will promote the best possible operation.
(*f*) Tests under way.

413-11678-520-90

SQUAT OF LARGE VESSELS IN SHALLOW WATER

(*b*) Canadian Coast Guard, Department of Transport.
(*d*) Experimental, applied research.
(*e*) 1/100 scale model study on the squat of tankers up to 227,000 D.W.T. running in shallow water. Use of radio-controlled self-powered model vessels, their vertical displacements being assessed by a laser beam/T.V. transmitter system.
(*f*) Suspended.
(*g*) Report submitted to the Canadian Coast Guard.

413-11679-470-90

DEVELOPMENT OF TERMINAL FACILITIES–MONTREAL HARBOUR

(*b*) Canadian Coast Guard, National Harbour Board, Department of Transport.
(*d*) Experimental.
(*e*) Study on an existing St. Lawrence River model (1/600 horizontal, 1/150 vertical). Impact of a proposed development in the Montreal Harbour with regard to water levels, current speeds, ice control and accessibility of the development.
(*f*) Completed.
(*g*) Report submitted to the Canadian Coast guard.

413-11680-470-90

GROS CACOUNA HARBOUR, SHIP MANOEVRING TESTS

(*b*) Canadian Coast Guard, Department of Transport.
(*d*) Experimental.
(*e*) Construction and calibration of a 1/150 scale model of the Gros Cacouna Harbour and neighbouring reach of the St. Lawrence River allowing to reproduce waves, wind, tidal level variations and tidal currents. Use of the radio-controlled model of a 110,000 D.W.T. bulk cargo carrier to study the harbour accessibility (approach channel design and manoeuvering techniques, simulation of tug-boat assistance).
(*f*) Completed.
(*g*) Report submitted to the Canadian Coast Guard.

413-11681-470-90

GROS CACOUNA HARBOUR, BROKEN ICE MOTION IN THE HARBOUR BASIN

(*b*) Canadian Coast Guard, Department of Transport.
(*d*) Experimental.
(*e*) Motion of the broken ice in and out of the harbour basin under the action of tidal currents, waves and wind. Determination of the rate of variation of the ice coverage in time as a function of wind direction. Study carried out on an 1/150 scale model of the Gros Cacouna Harbour and neighbouring reach of the St. Lawrence River, model ice made of polythene floats monitored by overhead T.V. cameras.
(*f*) Completed.
(*g*) Report submitted to the Canadian Coast Guard.

413-11682-340-73

LG-4 SPILLWAY–JAMES BAY PROJECT

(*b*) James Bay Energy Corporation; Rousseau, Sauvé, Warren Consulting Engineers, Montreal.
(*d*) Experimental; design.
(*e*) A 1/125 scale model study of the spillway and its dissipation basin design to carry a peak flow of 7600 m^3/s (268000 cfs). Investigation was made of the river-bed scour and resulting high levels downstream the powerhouse under various spillway flows and remedial measures were defined.
(*f*) Completed.

413-11683-860-97

CITY OF MONTREAL NEW WATER INTAKE

(*b*) City of Montreal; Water Distribution Division.
(*d*) Experimental; design.
(*e*) Increased water demand called for a second water intake located in the St. Lawrence River about 2000 feet from shore in currents up to 4 to 6 ft./sec. A 1/48 scale model of the 300 foot long structure was built to achieve proper flow distribution between four built-in chambers each one having a set of 10 ports. Design capacity was 660 MGD.
(*f*) Completed.

413-11684-860-97

CITY OF MONTREAL PUMPING STATION

(*b*) City of Montreal; Water Distribution Division.

(*d*) Experimental; operation.
(*e*) Study on a 1/12 scale model of a 96 inch temporary diversion conduit to allow chlorinated water to by-pass the main reservoir and adequately supply the pump sump. Required pumping capacity and satisfactory operation conditions were obtained by running the diversion circuit under partial vacuum.
(*f*) Completed.

413-11685-340-73

BRISAY WATER INTAKE AND CONTROL STRUCTURE–JAMES BAY PROJECT

(*b*) James Bay Energy Corporation; Asselin, Benoit, Boucher, Ducharme, Lapointe, Consulting Engineers, Montreal.
(*d*) Experimental; design.
(*e*) Study on a 1/60 scale model of an approach canal to the powerhouse water intakes and to a control structure made of five conduits disposed on two levels. Special care was paid to ice entrainment through the conduits and to the dissipation basin downstream.

UNIVERSITY OF MANITOBA, Department of Civil Engineering, Hydraulics Laboratory, Winnipeg, Manitoba, Canada R3T 2N2.

414-11711-350-73

GREAT FALLS DAM RECONSTRUCTION PROJECT

(*b*) Manitoba Hydro.
(*c*) Mr. E. K. Overgaard and Mr. P. D. Y. Wang, Civil Department, Generation Projects Division, Manitoba Hydro, Winnipeg, Manitoba, R3C 2P4.
(*d*) Design and operation project.
(*e*) A two-dimensional 1:48 scale model and a three-dimensional 1:64 scale model were used to determine the design requirements of spillway alternatives to be built downstream of the old dam and the amount of destruction and excavation to be performed. The maximum design discharge is 155,000 cfs and rigid control of water levels is required.
(*f*) Tests completed June, 1978.
(*h*) Manitoba Hydro internal report.

414-11712-220-90

SEDIMENT TRANSPORT OF SHALE SEDIMENT

(*b*) National Sciences and Engineering Research Council Canada.
(*d*) Experimental and applied research.
(*e*) An experimental investigation on a bed-load formula for shale sediments will be attempted using hydraulic flumes. Bed-load field data from the Wilson Creek experimental watershed, in west Manitoba will be used to calibrate the laboratory results. Tests on the threshold conditions, settling velocities of particles, and rate of sediment transport will be conducted.
(*f*) This research project is planned to last three years and was started in May, 1979.

414-11713-220-00

SNOW DRIFTING MODELS

(*d*) Field and laboratory applied research.
(*e*) The technique of using hydraulic flumes and fine sand to model snow drifting patterns has been tested. A model installed in an agricultural field has been used to correlate the results of flume tests. Scale effects, sand type, and wind direction effects have been investigated in this simulation study.
(*f*) The study was conducted during one year as an undergraduate thesis project.

McGILL UNIVERSITY, Department of Civil Engineering and Applied Mechanics, 817 Sherbrooke Street West, Montreal, PQ, Canada H3A 2K6.

415-11608-400-90

DESIGN CONSIDERATIONS FOR A HYBRID MODEL OF A TWO-DIMENSIONAL ESTUARY

(*b*) NRC.
(*c*) Professor L. D. Spraggs.
(*d*) Experimental and analytical.
(*e*) Development of procedures for coupling mathematical and physical models.
(*f*) Project just beginning.

415-11609-860-90

WATER QUALITY MODELING

(*b*) NRC, McGill University.
(*c*) Professor L. D. Spraggs.
(*d*) Analytical.
(*e*) Development of mathematical models for simulating winter conditions in reservoirs subject to thermal loading. Comparison of finite element and finite difference methods.
(*f*) Results expected beginning 1979.

415-11610-290-90

HYDRODYNAMIC MODELING

(*b*) NRC.
(*c*) Professor L. D. Spraggs.
(*d*) Analytical and experimental.
(*e*) Refinement of finite difference numerical models and comparison with data from laboratory physical models.
(*g*) Comparison of channel flow over stepped boundaries is underway. Effect of discretization on physical models and mathematical models is being studied.

415-11611-260-90

FLOW OF BULK SOLIDS

(*b*) National Sciences and Engineering Research Council of Canada.
(*c*) Professor S. B. Savage.
(*d*) Experimental and theoretical; basic research (Master's and Doctoral theses).
(*e*) Work is directed towards the development of constitutive equations that can be used for the analysis of bulk solids flow encountered in materials handling engineering, mineral and powder processing, as well as geophysical problems such as avalanches, debris flows and drift of pack ice.
(*g*) A number of experimental rigs have been devised to generate simple viscometric flows and thus acquire experimental information that can guide the development of realistic constitutive equations. These consist of flows in vertical and inclined open channels, various Couette flow apparatuses, and an annular shear cell. Velocity and stress distributions have been measured for various kinds of particles as functions of shear rate and particle concentration. Constitutive equations based upon these experiments have been devised and applied to the analysis of various flows.
(*h*) **Experiments on Shear Flows of Cohesionless Granular Materials,** S. B. Savage, *Proc. U.S.-Japan Seminar on Continuum-Mechanical and Statistical Approaches in the Mechanics of Granular Materials.* Gakujutsu Bunken Fukyukai, Tokyo, Japan, pp. 241-254, 1978.
Gravity Flow of Cohesionless Granular Materials in Wedge-Shaped Hoppers, S. B. Savage, M. Sayed, *ASME Applied Mechanics Summer Conference*, June 18, 1979, Niagara Falls, N.Y., *Mechanics Applied to the Transport of Bulk Materials. AMD* **31.**
Gravity Flow of Cohesionless Granular Materials in Chutes and Channels, S. B. Savage, *J. Fluid Mechanics* **92,** 1, 1979.

415-11612-870-90

HYDRODYNAMIC TRANSPORT OF POLLUTANT

(*b*) National Research Council of Canada.
(*c*) Dr. V. H. Chu, Associate Professor.
(*d*) Experimental and theoretical (Ph.D. thesis).
(*e*) Study of turbulent mixing and spreading characteristics of buoyant discharges.
(*g*) A number of model experiments were conducted to investigate the turbulent entrainment and spreading characteristics of gravity-stratified shear layers in both two and three dimensions. Flow visualization study was carried out by shadowgraph technique and quantitative measurements of velocity and density, including turbulent fluctuations, obtained with hot-film and electro-conductivity probes, respectively. The results were correlated by a set of scales derived from the concept of a "point source approximation." Based on experimental observations, a theoretical model was introduced. In this model, the growth and collapse of the three-dimensional shear layer have been described along radial streamlines. This approach is different from most one-dimensional models which require similarity assumptions of velocity and density distributions in both horizontal and vertical directions. Current work involves the study of low densimetric Froude number discharges and cross current effects.
(*h*) **Turbulent Gravity-Stratified Shear Flows,** R. E. Baddour, V. H. Chu, *Tech. Rept. No. 78-3 (FML)*, Dept. of Civil Engrg. and Applied Mechanics, McGill University, Montreal, Quebec, Canada, Sept. 1978.
Surface Thermal Plumes from Power Plants, V. H. Chu, R. E. Baddour, *Canadian Water Resources Assoc. Conf. on Environmental Aspects of Industrial Cooling in Northern Climates*, Edmonton, Canada, May 1978.
Unified Presentation of Buoyant Surface Jets in Three Dimensions, R. E. Baddour, V. H. Chu, *26th Ann. Hydraulics Div. Specialty Conf.*, Univ. of Maryland, U.S.A., pp. 811-818, Aug. 1978.
Development of Turbulent Mixing Layers at High Exit Richardson Number, R. E. Baddour, V. H. Chu, *XVIIth Congress of the IAHR* **1**, Baden-Baden, Fed. Rep. of Germany, pp. 317-324, Aug. 1977.

415-11613-870-90

THE SPREADING OF OIL ON THE SURFACE OF WATER

(*b*) Natural Sciences and Engineering Research Council Canada.
(*c*) Professor R. G. Cox.
(*d*) Experimental and theoretical; basic research.
(*e*) A study is made of the mechanisms responsible for the spreading of oil on a water surface.
(*g*) The basic equations governing the spreading of oil on a quiescent water surface were obtained for situations in which gravity and capillary forces cause spreading while viscous forces within the oil, inertia forces and boundary layer drag due to the water retard spreading. The spreading of very thin layers resulting from surface tension gradients due to layer thickness variations were also examined. Various similarity solutions have been obtained for simplified cases where particular forces dominate. These have been compared with experiment.
(*h*) **The Motion of Oil-Slicks on a Calm Sea,** N. D. Di Pietro, *M.Eng. Thesis*, 1975.
Similarity Solutions for the Spreading of Oil Slicks, M. A. Foda, *M.Eng. Thesis*, 1977.
The Spreading of a Very Viscous Liquid on a Water Surface, D. B. Ahn, *M.Eng. Thesis*, 1978.
The Hydrodynamics of the Spreading of One Liquid on the Surface of Another, N. D. Di Pietro, C. Huh, R. G. Cox, *J. Fluid Mech.* **84**, pp. 529-549, 1978.

McGILL UNIVERSITY, Marine Sciences Centre, 3600 University Street, Montreal, Quebec, Canada H3A 2T8. Dr. Grant Ingram, Chairman.

416-11606-860-90

VARIABILITY OF SUSPENDED MATTER IN THE ST. LAWRENCE ESTUARY

(*b*) National Research Council of Canada; Department of Education, Province of Quebec.
(*c*) Bruno d'Anglejan, Assoc. Professor.
(*d*) Field investigation; basic research; graduate student theses.
(*e*) A study of the variability of suspended matter concentration throughout the St. Lawrence estuary. Emphasis has been placed on trying to relate the changes of tidal currents, stratification and bottom topography to the observed changes. Simultaneously observed current and suspended matter profiles have been employed to investigate short period fluctuations in concentration resulting from advection and resuspension. Recently, a benthic tower has been constructed to obtain detailed near bottom profiles of suspended matter current and attenuance.
(*h*) **Time Depth Variations in Tidal Flux of Suspended Matter in the St. Lawrence Estuary,** B. d'Anglejan, R. G. Ingram, *Estuarine and Coastal Mar. Sci.* **4**, pp. 401-416, 1976.
On the Importance of Cross Channel Suspended Matter Flux in the Upper St. Lawrence Estuary, R. G. Ingram, B. d'Anglejan, *Environment Canada MS No. 43*, pp. 149-159, 1977.

416-11607-400-90

CIRCULATION AND MIXING IN ESTUARIES

(*b*) National Research Council of Canada; Department of Education, Quebec; Hydro-Quebec; James Bay Energy Corp.
(*c*) R. Grant Ingram, Assoc. Professor.
(*d*) Basic research employing a large amount of field investigation. Graduate theses on some of the material have been completed.
(*e*) To obtain an understanding of the relevant dynamical processes, long-term current meter moorings, and STD and current meter profiling were employed. Emphasis has been placed on three major estuaries in Quebec: St. Lawrence, Great Whale and Rupert Bay. All of the studies have been part of major interdisciplinary experiments.
(*h*) **Time Depth Variations in Tidal Flux of Suspended Matter in the St. Lawrence Estuary,** B. d'Anglejan, R. G. Ingram, *Estuarine and Coastal Mar. Sc.* **4**, 401-416, 1976.
Characteristics of a Tidal-Induced Estuarine Front, R. G. Ingram, *J. Geophys. Res.* **81**, 1951-1959, 1976.
On the Importance of Cross Channel Suspended Matter Flux in the Upper St. Lawrence Estuary, R. G. Ingram, B. d'Anglejan, *Proc. Symp. on Modeling of Transp. Mech. in Oceans and Lakes*, Burlington, Ont., *Environment Canada MS No. 43*, 149-159, 1977.
Nutrient Distribution in the St. Lawrence Estuary, P. Greisman, R. G. Ingram, *J. Fish. Res. Bd. Canada* **34**, 11, 2117-2123, 1977.
Internal Wave Observations Off Ile Verte, R. G. Ingram, *J. Mar. Res.*, 10 pp. (in press), 1978.

MEMORIAL UNIVERSITY OF NEWFOUNDLAND, Faculty of Engineering and Applied Science, St. John's, Newfoundland, Canada A1B 3X5.

417-10305-050-90

BUOYANT WALL JETS APPLIED TO OCEAN OUTFALLS

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) J. J. Sharp, Associate Professor and B. D. Vyas, Post-Doctoral Fellow.
(*d*) Experimental and theoretical research.

(e) Study of various mathematical models of ocean outfalls and development of a mathematical model for dilution achieved by an axisymmetric buoyant wall jet, and comparison with experimental results.
(f) Studies on two-dimensional buoyant wall jets continued.
(g) The research results could be utilized for an efficient design of ocean outfalls. The buoyant wall jets are found to have higher dilution capacity than the free jets discharged at the same Froude number and depth to diameter ratio.
(h) **The Buoyant Wall Jet,** J. J. Sharp, *Proc. ICE* **63,** 2, Sept. 1977.
Ocean Outfalls and Buoyant Wall Jets, J. J. Sharp, *3rd CSCE Atlantic Region Hydrotechnical Conf.*, Feb. 1978.
Submerged Discharges into Lakes, J. J. Sharp, *Conf. on Environmental Aspects of Industrial Cooling in Northern Climates*, Edmonton, May 1978.

417-10307-210-90

RESPONSE OF A SUBMERGED COMPOSITE PIPE

(b) National Research Council of Canada.
(c) Dr. D. B. Muggeridge, Associate Professor.
(d) Experimental and theoretical–M. Eng.
(e) Vibration characteristics of anisotropic cylindrical shells in a fluid medium have been investigated theoretically and confirmed experimentally. Numerical results are given for the following cases: A shell in air; a shell containing a fluid; a shell immersed in a fluid, and a shell containing a fluid that is immersed in a fluid.
(f) Completed.
(g) The presence of a fluid decreases the natural frequency of vibration by almost an order of magnitude.
Results for a shell immersed in a fluid and a shell containing a fluid are almost identical.
Even lower frequencies occur when a shell containing a fluid is submerged.
The natural frequency of a shell, that is partially submerged, decreases rapidly until the shell is approximately one quarter submerged. Thereafter the natural frequency is relatively insensitive to further submergence.
(h) **Dynamics of a Fluid Conveying Fiber-Reinforced Shell,** D. B. Muggeridge, T. J. Buckley, *AIAA J.*, to be published June 1979.
Flexural Vibration of Orthotropic Cylindrical Shells in a Fluid Medium, D. B. Muggeridge, T. J. Buckley, *AIAA J.*, to be published Oct. 1979.

417-10308-430-90

WAVE FORCES ON MARINE STRUCTURES

(b) National Research Council of Canada.
(c) Dr. D. B. Muggeridge, Associate Professor.
(d) Experimental and theoretical, M. Eng. thesis.
(e) A 60 m × 4.5 m × 3 m wave tank has been commissioned and calibrated. The transfer function for the board has been established for regular and random waves and reflection coefficients of the beach have been measured. Drag, lift, and inertia coefficients have been obtained for a rigid PVC circular cylinder for Reynolds and Keulegan-Carpenter numbers between $8(10)^3$ and $2(10)^5$ and 0.7 and 12 respectively.
(h) **Calibration of a 60 m Wave Tank and a Study of the Response of a Circular Cylinder to Sinusoidal Waves,** C.-M. Chen, *M.Eng. Thesis*, available from the Ocean Engineering Information Centre.

417-10309-840-90

SEASONAL FLOW IN CHANNELS DRAINING PEATLANDS

(b) Natural Sciences and Engineering Research Council of Canada.
(c) J. Waterhouse, Assoc. Professor.
(d) Field investigation, design.
(e) Seasonal changes in groundwater level, in soil moisture, in peat characteristics and in the drainage channel conditions contribute to flow variations. Data obtained from field work will be used to predict channel flows, special attention being paid to freezing conditions.

417-10310-140-90

HEAT, MASS, AND MOMENTUM TRANSFER IN THE MELTING OF ICE IN SALINE WATER

(b) Natural Sciences and Engineering Research Council of Canada.
(c) N. W. Wilson, Assoc. Professor.
(d) Theoretical and experimental; basic and applied.
(e) The boundary layer regions near an ice wall melting into saline water are being investigated to provide information concerning combined free and forced convection. Geometries considered include a horizontal ice sheet with flow above or below the sheet, and a vertical ice sheet. Will provide information pertaining to characteristics of iceberg and sheet ice melting in saline water.
(g) Enhancement of melting rates occur in the horizontal case because of buoyancy forces. Additionally, at combined convection conditions, small recirculating zones occur within the boundary layers.

417-11323-240-90

HYDROELASTIC RESPONSE OF A VISCOELASTIC PLATE VIBRATING IN A FLUID

(b) Natural Sciences and Engineering Research Council of Canada.
(c) Dr. M. Booton, Assistant Professor.
(d) Experimental, theoretical and applied research.
(e) This research program consists of (1) analysis of a cantilever plate vibrating in a fluid, utilizing various viscoelastic models for the structural material; (2) experiments with cantilever plates vibrating in water in order to determine damping characteristics.
(g) Response of beam-type structures vibrating in air obtained so far.
(h) None in this particular area.

417-11324-210-90

CIRCULAR PIPE FLOW

(b) Natural Sciences and Engineering Research Council Canada.
(c) Dr. J. D. Malcolm, Associate Professor.
(d) Theoretical, design.
(e) Linear graph theory is applied to steady flow pipe design problems with up to four unknowns providing alternative strategies for solution of simultaneous equations which result.
(f) Completed.
(h) **A GraphiCal Calculation Method for Pipe Problems,** J. D. Malcolm, *3rd CSCE Atlantic Region Hydrotechnical Conf.*, Feb. 1978.

417-11325-240-90

SEISMIC RESPONSE OF ELEVATED LIQUID STORAGE TANKS

(b) Natural Sciences and Engineering Research Council of Canada.
(c) Dr. D. V. Reddy, Professor.
(d) Theoretical research–M.Eng.
(e) The need for predicting the response of liquid storage tower structures, incorporating the action of the tank, has prompted this investigation. The liquid, which fills the tank partially or completely, is assumed to be inviscid and incompressible. A finite element model is presented for the dynamic analysis of the structure. The liquid sloshing effect on the tank wall is incorporated. Rayleigh damping is assumed, allowing the equations of motion to be uncoupled. A digitized acceleration of an earthquake is provided as the ground excitation input, and the displacement response of the whole system determined by mode superposition. The stresses in the tank walls and the internal forces at the frame nodes are then computed.
(f) Work in progress.

(*h*) **Seismic Response of Elevated Liquid Storage Tanks,** S. C. Lee, D. V. Reddy. Abstract of paper accepted for presentation at the *U.S. Natl. Conf. on Earthquake Engineering*, Stanford University, Calif., Aug. 1979.

417-11326-430-90

FREQUENCY TUNING OF OFFSHORE PLATFORMS BY LIQUID SLOSHING

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Dr. D. V. Reddy, Professor.
(*d*) Theoretical research, M.Eng.
(*e*) The structural response of offshore platforms is determined for a digitized wave height spectrum, with and without the liquid-filled container in operation. The mass damper effect of the liquid-filled container is discussed. The platform is also analyzed to determine the variation of the system response with damper parameters (i.e., liquid levels), and the damper effectiveness for varying wave spectral inputs.
(*f*) Work in progress.
(*h*) **Frequency Tuning of Offshore Platforms by Liquid Sloshing,** S. C. Lee, D. V. Reddy. Abstract of paper accepted for presentation at the *Intl. Conf. on Engrg. for Protection from Natural Disasters*, Bangkok, Thailand, Jan. 7-10, 1980.

417-11327-430-90

WAVE INDUCED DYNAMIC RESPONSE OF PIPES BURIED IN PERMEABLE BEDS

(*b*) Natural Sciences and Engineering Research Council Canada.
(*c*) Dr. D. V. Reddy, Professor.
(*d*) Theoretical research.
(*e*) The wave-induced response of a concrete-coated submarine pipe, buried in a permeable bed, is studied taking into account the compressibility of the water and soil.
(*f*) Work in progress.
(*h*) **Wave-Induced Dynamic Response of Pipes Buried in Permeable Beds,** A. K. Haldar, W. Bobby, D. V. Reddy, M. Arockiasamy. Abstract of paper accepted for presentation at *Conf. on Behaviour of Off-Shore Structures (BOSS)*, London, England, Aug. 1979.

417-11328-430-90

RESPONSE OF RUBBLE MOUND BREAKWATERS TO WAVE AND SEISMIC FORCES

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Dr. D. V. Reddy, Professor.
(*d*) Theoretical research.
(*e*) The response of rubble-mound breakwaters to wave and seismic forces has been determined using dynamic finite element analysis. The hydrodynamic resistance of the seawater is included and the behaviour of the breakwater for the most probable breaking height of wave, obtained from the spectra, having a Rayleigh type distribution, is compared with that for a corresponding design wave height. The maximum, dynamic pressures are calculated using the theory of similarity and dimensional analysis reported by Krylov. The effect of the foundation stiffness is included in the response study for wave loading. Parameteric studies are carried out for different forcing slopes and wave periods. In the seismic analysis a portion of the Taft accelerogram E-W of 6-8 seconds is considered.
(*f*) Completed.
(*g*) Foundation-structure interaction decreases the frequencies of the structure. The influence of the elasticity of the foundation on the structural response appears significant. The fundamental frequency of the breakwater resting on a rocky bed layer is considerably higher than that on dense sand. In most cases the maximum stresses occur at the base of the breakwater.
(*h*) **Response of Rubble Mound Breakwaters to Wave and Seismic Forces,** M. Arockiasamy, D. V. Reddy, T. K. Yen, *Proc. PORTS 77, ASCE Conf.*, Long Beach, Calif., Mar. 9-11, 1977.

417-11329-430-90

DYNAMIC WAVE-WATER-SOIL-STRUCTURE INTERACTION OF AN OFFSHORE GRAVITY PLATFORM

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Dr. D. V. Reddy, Professor.
(*d*) Theoretical research.
(*e*) The dynamic response analysis of a large diameter offshore prestressed concrete gravity platform-foundation system subjected to wave loading, has been studied. The general purpose programme, SAP-IV, is melded with software specially developed for the computation of wave forcing functions, and shear strain amplitudes at the soil element centroids. The wave forces on the tower are determined based on Stokes' third order wave theory and on the caisson using the McCamy-Fuchs linear diffraction theory. The wave lengths are determined based on the wave height, wave period and water depth using an iterative procedure.
(*f*) Completed.
(*g*) The difference between the fundamental frequency for the rigid base condition differs and that for a semi-rigid base with linear soil behaviour is less then 5 percent. However, the frequency reduction is much larger for a semi-rigid base with nonlinear soil behaviour. The axial force and moment induced at the bottom of the tower varies depending on the method of analysis.
(*h*) **Dynamic Wave-Water-Soil-Structure Interaction of an Offshore Gravity Platform Including Nonlinear Soil Behaviour,** M. Arockiasamy, A. K. Haldar, D. V. Reddy, T. K. Yen, *Proc. 2nd SAP User's Conf. and Workshop*, Los Angeles, Calif., June 1977.
Dynamic Wave-Structure-Soil Interaction Studies of Offshore Structure Considering Soil Nonlinearity, M. Arockiasamy, D. V. Reddy, A. K. Haldar, T. K. Yen, *Proc. Symp. Appl. of Computer Method in Eng.*, Univ. Southern Calif., Los Angeles, Calif., Aug. 23-26, 1977.

417-11330-430-90

PROBABILISTIC SEISMIC FLUID-STRUCTURE INTERACTION OF FLOATING NUCLEAR PLANT PLATFORMS

(*b*) National Sciences and Engineering Research Council of Canada.
(*c*) Dr. D. V. Reddy, Professor.
(*d*) Theoretical research–Ph.D.
(*e*) The probabilistic dynamic response to seismic forces is investigated in the frequency domain for a Floating Nuclear Plant (FNP) Platform, restrained by mooring struts attached to caissons, within a protective breakwater. The offshore nuclear power plant, similar to the one proposed for the Atlantic Generating Station, is chosen as the example problem. The fluid medium is discretized using two-dimensional plane strain eight-noded isoparametric quadrilateral finite elements with pressures as the modal unknowns. The fluid structure interaction is simulated by incorporating the hydrodynamic forces, associated with frequency-dependent added mass and damping, as external loading at the interfacial nodes of the FNP platform.
(*f*) Continuing work on coupled fluid-structure interaction.
(*g*) The displacement in the time domain, the mean square response, standard deviation, and central frequency at the centre of FNP are obtained. For a number of ground motion records having the same duration, the extreme-value probability distribution function can be used to obtain the peak values.
(*h*) **Stochastic Response of Floating Nuclear Plants to Seismic Forces,** M. Arockiasamy, D. V. reddy, P. V. Thangam Babu and A. K. Haldar, *Proc. 5th Natl. Mtg. Universities Council of Earthquake Engineering Research (UCEER)*, Cambridge, Mass., U.S.A., June 23-24, 1978.
Probabilistic Seismic Fluid-Structure Interaction of Floating Nuclear Plant Platforms, P. V. Thangam Babu, M.

Arockiasamy, D. V. Reddy. Paper accepted for presentation at the *5th Intl. Conf. Structural Mechanics in Reactor Technology*, Berlin, Germany, Aug. 13-17, 1979.

417-11331-870-90

OCEAN OUTFALL PRE-DILUTION DEVICES

(*b*) Natural Sciences and Engineering Research Council Canada.
(*c*) Dr. J. J. Sharp.
(*d*) Experimental and theoretical.
(*e*) Study of various devices used to increase dilution at ocean outfalls.
(*g*) Use of most pre-dilution devices is limited. Dilutions may be increased by a factor of 2 times but not significantly more.
(*h*) **Limitations of Devices to Improve Dilution of Ocean Outfalls,** J. J. Sharp, *Proc. ICE* **65**, 2, Dec. 1978.
Methods of Improving the Dilution of Ocean Outfalls, J. J. Sharp, *Effluent and Water Treatment Journal*, in press.

417-11332-420-00

WAVE HEIGHT AND PERIOD PREDICTION

(*c*) Dr. J. J. Sharp.
(*d*) Empirical.
(*e*) Application of similarity to prediction of deep water, wind driven waves.
(*f*) Completed.
(*g*) Results presented in single dimensionless diagram for wave height and period; covers fully arisen sea, fetch limited and duration limited waves.
(*h*) **Unified Dimensionless Wave Diagram,** J. J. Sharp, *3rd CSCE Atlantic Region Hydrotechnical Conf.*, Feb. 1978.
Simplified Approach to Prediction of Deep Water, Wind Driven, Waves, J. J. Sharp, *Dock and Harbour Authority* **LVIII**, 687, Feb. 1968.

417-11333-340-00

SURGE TANK ANALYSIS

(*c*) Dr. E. Moore and Dr. J. J. Sharp.
(*d*) Theoretical.
(*e*) Development of approximate equations for direct, non-iterative solution to surge tank problems.

NATIONAL RESEARCH COUNCIL, Division of Mechanical Engineering, Hydraulics Section, Montreal Road, Ottawa, K1A 0R6, Canada. J. Ploeg, Section Head.

418-08133-420-00

FORCES ON OFF-SHORE STRUCTURES

(*c*) Dr. G. R. Mogridge, W. W. Jamieson.
(*d*) Experimental, theoretical; applied research.
(*e*) Wave forces have been measured on submerged water outfall or intake structures, using regular and irregular waves.
(*f*) Completed.
(*h*) **Non-Breaking and Breaking Wave Loads on a Cooling Water Outfall,** G. R. Mogridge, W. W. Jamieson, *Proc. 16th Coastal Engrg. Conf.*, Hamburg, Sept. 1978.

418-10314-430-00

BREAKWATER STABILITY STUDY

(*c*) J. Ploeg, Dr. E. P. D. Mansard.
(*d*) Experimental; applied research.
(*e*) A study to improve breakwater stability tests in laboratories, by using new techniques of generating realistic sea states and considering the strength aspects of model armour units.
(*g*) Wave grouping effects affect stability criteria of breakwaters. Model tests of large armour units require simulation of strength of concrete.
(*h*) **Effects of Wave Grouping on Breakwater Stability,** R. R. Johnson, E. P. D. Mansard, J. Ploeg, *Proc. 16th Coastal Engrg. Conf.*, Hamburg, Sept. 1978.
Model Tests of Sines Breakwater, E. P. D. Mansard, J. Ploeg, Natl. Research Council of Canada, Div. of Mechanical Engrg., *Hydraulics Lab. Tech. Rept. LTR-HY-67*, Oct. 1978.

418-10315-720-00

SIMULATION OF IRREGULAR WAVES IN LABORATORY FLUMES

(*c*) E. Mansard, E. Funke.
(*d*) Experimental, theoretical, basic research.
(*e*) A study to develop new techniques to simulate ocean wave conditions, including wave grouping effects.
(*g*) The definition of the phase spectrum in an irregular sea state is an important parameter.
(*h*) **Reproduction of Prototype Random Wave Trains in a Laboratory Flume,** E. P. D. Mansard, E. R. Funke, Natl. Research Council of Canada, Division of Mechanical Engineering, *Hydraulics Laboratory Tech. Rept. LTR-HY-64*.
SPLSH–A Program for Synthesis of Episodic Waves in a Laboratory Flume, E. R. Funke, E. P. D. Mansard, Natl. Research council, Div. of Mechanical Engrg., *Hydraulics Lab. Tech. Rept. LTR-HY-65*.
On the Synthesis of Realistic Sea States, E. R. Funke, E. P. D. Mansard, Natl. Research Council of Canada, Div. of Mechanical Engrg., *Hydraulics Lab. Tech. Rept. LTR-HY-66*.
On the Meaning of Phase Spectra in the Fourier Transform of Random Wave Trains, E. R. Funke, E. P. D. Mansard, Natl. Research Council of Canada, Div. of Mechanical Engrg., *Hydraulics Laboratory Tech. Rept. LTR-HY-68*.
The Measurement of Incident and Reflected Spectra Using a Least Squares Method, E. P. D. Mansard, Natl. Research Council of Canada, Div. of Mechanical Engrg., *Hydraulics Laboratory Technical Report LTR-HY-72*.

418-10316-420-90

MOORING FORCES ON FLOATING STRUCTURES

(*b*) Transport Canada.
(*c*) Dr. E. P. D. Mansard, Dr. B. D. Pratte.
(*d*) Experimental, theoretical, applied research.
(*e*) A study to determine forces on and motions of offshore structures, including vessels moored in shallow water exposed to waves.

418-11334-430-90

WAVE IMPACT PRESSURES ON VERTICAL WALL STRUCTURES

(*b*) Public Works Canada.
(*c*) Dr. G. R. Mogridge, W. W. Jamieson.
(*d*) Experimental, theoretical; applied research.
(*e*) A study to determine magnitudes and distribution in time and space of peak pressure forces by breaking and non-breaking waves on vertical wall structures.
(*g*) Previously reported tests results have often been misleading due to limited response characteristics of transducers and recording equipment.
(*h*) **Wave Impact Pressures on Composite Breakwaters,** G. R. Mogridge, W. W. Jamieson, to be presented at the *17th Coastal Engrg. Conf.*, Sydney, Australia, 1980.

418-11335-410-00

SEDIMENT TRANSPORT BY WAVES

(*b*) Internal.
(*c*) D. H. Willis.
(*d*) Experimental, theoretical; applied research.
(*e*) An irregular wave machine is used in a beach flume to measure total amounts of sediment in motion over a horizontal bed in the presence of waves and currents.
(*h*) **Sediment Load Under Waves and Currents,** D. H. Willis, *Proc. 16th Coastal Engrg. Conf.*, Hamburg, Sept. 1978.

418-11336-400-00

HYBRID MODELING OF TIDAL ESTUARIES

(*b*) Internal.
(*c*) N. L. Crookshank, E. R. Funke.
(*d*) Experimental; applied research.
(*e*) A physical and a mathematical model of sections of the St. Lawrence river have been dynamically coupled to run as one system. The mathematical model uses Array Processors.
(*g*) It has been shown that hybrid modeling techniques can successfully be used to allow larger physical models of relatively small areas in tidal estuaries without having an effect of the tidal boundaries in the test results.
(*h*) **A Hybrid Model of the St. Lawrence River Estuary,** E. R. Funke, N. L. Crookshank, *Proc. 16th Coastal Engrg. Conf.*, Hamburg, Sept. 1978.
Modeling Requirements and Techniques for Tidal Power Developments in the Bay of Fundy, E. R. Funke, J. Ploeg, N. L. Crookshank, Natl. Research Council of Canada, Div. of Mechanical Engrg., *Hydraulics Laboratory Tech. Rept. LTR-HY-71*, Mar. 1979.

UNIVERSITY OF NEW BRUNSWICK, Department of Civil Engineering, Fredericton, New Brunswick, E3B 5A3, Canada. Dr. K. S. Davar, Professor of Civil Engineering.

419-11635-220-96

SCOUR AT CULVERT OUTLETS

(*b*) New Brunswick Department of Transportation.
(*c*) Dr. Dale I. Bray.
(*d*) Experimental and field investigation; applied research; Master's thesis.
(*e*) Evaluation of the effect of the downstream channel width on the scour hole geometry at culvert outlets. Three sizes of culverts were used in the laboratory experiment with one bed material size (5.5 mm). Field studies were carried out to measure actual scour hole geometry downstream of culverts.
(*f*) Completed.

ONTARIO HYDRO, 700 University Avenue, Toronto, Ontario, Canada M5G 1X6. Mr. D. G. Harkness, Manager, Hydraulic Studies and Development Department.

421-09579-340-00

WESLEYVILLE GENERATING STATION–CONDENSER COOLING WATER SYSTEM

(*d*) Experimental; design.
(*e*) A 1:25 scale model comprising the vertical inlet shaft, forebay, pumpwell inlets, condenser outlets, return duct, outfall channel, as well as an internal recirculation duct to release warm water into the forebay under icing conditions and a tempering pumphouse to pump cold water into outfall channel for reduction of temperature of cooling water at the point of return to Lake Ontario. Model used to determine details of hydraulic design and to check cooling water system performance for this 2000 MW oil-fired thermal station.
(*f*) Investigation completed, model inactive.

421-09581-340-00

ONCE-THROUGH CONDENSER COOLING WATER SYSTEMS–INTAKE DEVELOPMENT

(*d*) Experimental; development.
(*e*) A facility to carry out development work of offshore submerged condenser cooling water intakes for large fossil-fired and nuclear thermal generating stations. Studies aim at developing a number of intake designs with suitable characteristics regarding plant operation and protection of the environment.
(*f*) Facility operational.

421-10318-420-00

SUBMERGED CONDENSER COOLING WATER INTAKE STRUCTURES-WAVE LOADS

(*d*) Experimental; design.
(*e*) A model test programme to ascertain wave forces and pressure distributions on large submerged cooling water intake structures for three nuclear generating stations. Tests conducted with 1:25 and 1:50 scale models.
(*f*) Experimental investigation completed.

421-10320-340-00

PICKERING GENERATING STATION "B" COOLING WATER OUTFALL TEMPERING

(*d*) Experimental; design.
(*e*) A 1:60 scale model of the condenser cooling water return structure. Model used for the hydraulic design of a side outlet to introduce water at ambient temperature into the condenser coolant stream for reduction of temperatures to conform with environmental guidelines. Design objective: efficient mixing of warm and cold water streams to achieve uniform temperatures at the monitoring point.
(*f*) Investigation completed, model dismantled.

421-10324-340-00

BRUCE NUCLEAR COMPLEX

(*d*) Experimental; design; operation.
(*e*) A scale model–horizontal scale 1:240, vertical scale 1:120–featuring the cooling water outlets of three nuclear generating stations and one large heavy water production facility. Objective of study is to ascertain the deployment and interaction of the four thermal plumes to ensure satisfactory operating conditions and compliance with environmental guidelines.
(*f*) Investigation completed, model adapted to Once-Through Cooling studies.

421-10325-340-00

DARLINGTON GENERATING STATIONS "A" AND "B"

(*d*) Experimental; design.
(*e*) A scale model–horizontal scale 1:250, vertical scale 1:125–of the condenser cooling water intake and outfall, including the adjacent area of Lake Ontario, affected by the once-through cooling process. Model used to study hydraulic design details of intake and outfall works to prevent cooling water recirculation and to improve efficiency of heat dispersion of cooling water waste heat.
(*f*) Investigation in progress.

421-10328-220-00

MARMION LAKE–SEDIMENT ENTRAINMENT STUDY

(*d*) Experimental; field investigation; design.
(*e*) Field sampling and laboratory test programme to establish sediment entrainment characteristics. Results to be used to determine the response of Lake bed sediments, consisting of very fine grained mine tailings to flow in the Lake to be induced by the circulation of condenser cooling water by a proposed thermal generating station.
(*f*) Investigation completed, test facility dismantled.

421-11337-340-00

BRUCE GENERATING STATION "A"–MAIN STEAM PIPES BALANCE HEADER

(*d*) Experimental; applied research.
(*e*) 1:6 scale model of the balance header including portions of the steam lines upstream and downstream of the balance header. Water employed to simulate flow of steam. Model used to determine experimentally the extent of pressure fluctuations generated by the flow in the

balance header, as possible sources of main steam lines vibration.
(*f*) Completed; model dismantled.

421-11338-340-00

DARLINGTON GENERATING STATION "A"–COOLING WATER FOREBAY

(*d*) Experimental; design.
(*e*) A 1:30 scale model of the cooling water intake tunnel, forebay channel, pumphouses, and recirculation system. The model is used to (i) measure the velocity distribution throughout the forebay for assessment of entrained fish bypass of the cooling water pumphouses for removal through a fish pumphouse; (ii) evaluate the current patterns approaching the pumphouses; and (iii) determine, and possibly modify, the mixing of the warm water injected to prevent ice formation.
(*f*) Investigation in progress.

421-11339-340-00

DARLINGTON GENERATING STATION "A"–DOUSING SYSTEM

(*d*) Experimental; design.
(*e*) A 1:16 scale model of the dousing system including the water storage tank, siphon risers, central passage and lower seal or distribution chamber. Model used to determine experimentally the loss coefficients of the various parts of the system under steady operating conditions.

421-11340-340-00

DARLINGTON GENERATING STATION "A"–SPRAY HEADERS

(*d*) Experimental; design.
(*e*) An investigation to determine the optimum distribution of spray plates on the spray header for uniform dousing in the low pressure containment building. A 1:3 scale model of the dome-shaped spray plate mounted on a header was used to determine the dependence of the spray plate's discharge coefficient on flow velocity in the header.
(*f*) Investigation completed, model inactive.

421-11341-300-00

TWELVE MILE CREEK–RIVER CROSSING

(*d*) Experimental; design.
(*e*) A 1:60 scale hydraulic model study to determine the influence of bridge piers on the flow characteristics and channel stability.
(*f*) Investigation completed; model dismantled.

421-11342-340-00

DARLINGTON GENERATING STATION "A"–DOUSING SYSTEM INSTABILITIES

(*d*) Experimental; theoretical, applied research.
(*e*) A 1:16 scale model of the dousing system including the water storage tank, siphon risers, upper chamber, central passage and lower seal chamber. Model used to determine experimentally the nature of pressure and velocity oscillations and to predict possible flow instabilities in the prototype dousing system.
(*g*) Dominant oscillation frequency strongly dependent on the volume of the upper chamber.

421-11343-340-00

ONCE-THROUGH COOLING–NEARSHORE MIXING

(*d*) Experimental; development.
(*e*) A scale model–horizontal scale 1:250, vertical scale 1:125 of a condenser cooling water intake and outfall including the adjacent area of a lake, affected by the once-through cooling process. Model used to study the nearshore mixing characteristics of a surface discharge for the development of environmental guidelines.

421-11344-340-00

ATIKOKAN GENERATING STATION–COOLING WATER INTAKE

(*d*) Experimental; design.
(*e*) A 1:20 scale model of the submerged nearshore intake and tunnel transition. Model used for the hydraulic design of the tunnel inlet area to achieve even velocity distribution and prevent vortex formation.

421-11345-340-00

ATIKOKAN GENERATING STATION–COOLING WATER FOREBAY

(*d*) Experimental; design.
(*e*) A 1:20 scale model of tunnel outlet transition and pumphouse forebay. Model used for the hydraulic design of the rock-cut forebay, to ensure acceptable velocity distribution at critical flow cross-sections.
(*f*) Investigation in progress.

421-11346-340-00

ONCE-THROUGH-COOLING–MATHEMATICAL MODEL VERIFICATION

(*d*) Experimental, development.
(*e*) A 1:120 scale model of a condenser cooling water surface discharge channel and adjacent area of a large body of water. Model used to determine experimentally the discharge plume properties at densimetric Froude numbers of 3, 5 and 7. The experimental results to be used to verify a mathematical model.

421-11347-050-00

ONCE-THROUGH CONDENSER COOLING WATER SYSTEMS–SUBMERGED BUOYANT JETS (PROJECT I)

(*d*) Experimental; development.
(*e*) A test tank 2.80 × 2.45 × 0.40 m with an adjustable bottom. Three-dimensional temperature measurements used for parameteric analysis of the behaviour of submerged single-port discharges in shallow water. The parameters examined are densimetric Froude number (7-26), relative submergence (1.0-3.0) and discharge angle (0°-40°).
(*f*) Experimental investigation completed, model inactive.

421-11348-050-00

ONCE-THROUGH CONDENSER COOLING WATER SYSTEMS–SUBMERGED BUOYANT JETS (PROJECT II)

(*d*) Experimental; development.
(*e*) A test basin 47 × 35 m with sloping bottom. Three-dimensional temperature measurements used for parametric study of the behaviour of horizontal submerged single-port as well as branched outfalls. The parameters examined are densimetric Froude number (7-33), relative submergence (1.4-4.1) and relative branch-spacing (7.2-28.9).
(*f*) Investigation in progress.

UNIVERSITY OF OTTAWA, Department of Civil Engineering, Hydraulics Laboratory, Ottawa, Canada K1N 9B4. Professor D. R. Townsend, Laboratory Director.

422-09583-390-00

HYDRAULIC PERFORMANCE OF VERTICAL FLARED INLETS TO SERVICE RESERVOIRS

(*c*) Professor D. R. Townsend.
(*d*) Experimental; Master's thesis.
(*e*) The hydraulic performance of a number of model flared inlets, of different geometries, is being investigated to produce suitable data for the design of prototype structures.
(*f*) Completed.

(*g*) 10 different units, with length to (inlet) pipe diameter rations L/D = 3 and 6, were tested including linear expansions, having internal angles of 7°, 20°, 33° and 45°, and a "bellmouth" expansion with a crest length equal to that for the 33° linear expansion. Performance criteria were based on stability of the turbulent free-surface plumes generated at the crest of the units and the height of the plume above the crest elevation for a wide range of flows. A 33° linear pipe expansion (L/D = 6) gave the best overall performance among the units tested.

422-09584-870-90

HYDRAULICS OF JUNCTION MANHOLES

(*b*) National Research Council of Canada.
(*c*) Professor D. R. Townsend.
(*d*) Experimental; Master's thesis.
(*e*) Models of different basic arrangements and geometries for stormwater sewer junctions are being investigated with a view to minimizing the head losses across such structures.
(*f*) Completed.
(*g*) Of the various model junction configurations tested (using mainly 45° and 90° laterals) the most effective junction shape employed U-Shaped transitions in the junction structure. This arrangement avoided abrupt expansion and contraction of the flows entering and exiting the structure and consequently resulted in minimal associated energy losses. While the provision of a small deflector plate at teh confluence of the entering streams produced only minor improvement in the overall performance of the 45° junction this feature resulted in a marked improvement in the performance of the 90° junction configuration. With regard to the elimination of backwater during normal operation of storm sewer systems the study also confirmed the importance of providing suitable invert drops across major junction structures.
(*h*) **Laboratory Study of Energy Losses at Storm Sewer Junctions,** J. R. Prins, D. R. Townsend, *Proc. ASCE Irrigation and Drainage Division's Specialty Conf.: Environmental Aspects of Irrigation and Drainage*, Univ. of Ottawa, pp. 609-625, July 1976.
Performance of Model Storm Sewer Junctions, D. R. Townsend, J. R. Prins, *J. Hydraulics Div., ASCE* **104**, HY1, pp. 99-104, Jan. 1978.

422-09587-220-90

SUSPENDED SEDIMENT FROM URBAN DEVELOPMENT

(*b*) National Research Council of Canada
(*c*) Dr. R. G. Warnock.
(*d*) Field and theoretical, basic research for Doctor's degree.
(*e*) Factor analysis of data gathered on suspended sediment loads in streams from areas undergoing rapid development.
(*f*) Completed.
(*g*) Streams in Western Quebec were sampled during the spring, summer and fall months of 1973, 1975 and 1976 to determine suspended sediment yield. This yield was related to hydrologic, physiographic land use and geologic characteristics of the area. Factor analysis with varimax rotation was applied to the data to determine the four significant factors. Physical meanings were attached to these factors and a prediction equation developed by mulitvariate regression.

422-09588-300-90

SUSPENDED SOLIDS AND DIFFUSION IN THE OTTAWA RIVER

(*b*) National Research Council of Canada.
(*c*) Dr. R. G. Warnock.
(*d*) Field, applied research.
(*e*) Investigation of temporal variation of suspended solids and measurements of turbulent diffusion in the Ottawa River.
(*f*) Completed.
(*g*) Studies of the temporal variation of suspended sediment for two years, 1975 and 1976, showed that the peak flow rate of suspended solids in the Ottawa River at Ottawa precedes the peak flow rate from snow melt runoff. Similar occurrences have also been observed in tributoring flows. Studies of lateral diffusion in the Ottawa River through the use of fluorescent dye gave the following formula for the lateral diffusion coefficient. $K_2 = .043\ d\overline{U}_x$ in which d is the depth and $\overline{U}_x$ is the mean velocity in the longitudinal direction. The measurements were taken at a location where turbulence could be expected to be high because of channel geometry, rapids and tributary inflows.
(*h*) **Seasonal Variation of Suspended Sediment Transport in the Ottawa River,** R. G. Warnock, *Transport Processes and River Modeling Workshop*, Nov. 20, 21, 1978, NWRI, Burlington, Ont.
Field Study of Lateral Diffusion in the Ottawa River, M. A. Meseal, R. G. Wzrnock, *Transport Processes and River Modeling Workshop*, Nov. 20, 21, 1978, NWRI, Burlington, Ontario.
Chapters 4, 11; *Final Report, Ottawa River Project, National Research Council, Ottawa, Canada, July 1977.*

422-11349-870-90

REMOVAL OF NUTRIENTS FROM WASTEWATER APPLIED TO SOIL

(*b*) NSERC Canada.
(*c*) Dr. R. G. Warnock.
(*d*) Experimental, applied research, Doctoral thesis.
(*e*) Study is to determine removal of nitrogen and phosphorous in various methods of application of waste water to soil.
(*g*) Results are available on soil column experiments performed at room temperature and at 4 °C using septic tank effluent in which removals of nitrogen and phosphorous were monitored.
(*h*) **Column Study of Nutrient Removal from Septic Tank Effluent for Warm and Cold Temperatures,** D. K. K. Chan, *Final Year Thesis*, Dept. Civil Engrg., Univ. of Ottawa, May 1978.

422-11350-870-90

DISTRIBUTION OF DO AND COD DOWNSTREAM OF A POLLUTANT SOURCE IN THE OTTAWA RIVER

(*b*) NSERC Canada.
(*c*) Dr. R. G. Warnock.
(*d*) Field, applied research.
(*e*) Study is to determine longitudinal and lateral variations of DO and COD downstream of a wastewater outfall in the Ottawa River.
(*h*) **A Field Investigation of the Dissolved Oxygen in the Ottawa River,** H. Sutanto, *Final Year Thesis*, Dept. Civil Engrg., Univ. of Ottawa, May 1978.

422-11351-200-90

STOCHASTIC PREDICTION OF SHEAR STRESS DISTRIBUTIONS AT THE BED OF OPEN CHANNEL BENDS

(*b*) National Research Council of Canada.
(*c*) Professor D. R. Townsend.
(*d*) Theoretical and experimental, basic research towards a Doctoral degree.
(*e*) The main objective of this research program was the development, validation and subsequent comparison of various stochastic-type numerical models to predict, for a steady uniform approach flow condition, the stable bed shear stress distribution (and related bed topography) in the vicinity of a bend in an open (sand-bed) channel.
(*f*) Completed.
(*g*) A detailed investigation of the flow field in a wide open-channel bend was performed, and the influence of associated secondary currents monitored, in a representative physical model of the system. The laboratory study describes a methodology whereby bed shear stress distribution in the bend was computed using single-point velocity measurements therein. Subsequent comparison, between predicted distributions (numerical models) and measured distributions (physical model), favoured the use of a finite

Fourier Series (second order autoregressive) model. In the theoretical study an equation is presented which defines the extent of channel influenced by the secondary currents generated in the bend.

422-11352-870-00

MODEL STUDY OF A CHOKING DEVICE FOR A STORM-SEWER CATCHBASIN STRUCTURE

(*c*) Professor D. R. Townsend.
(*d*) Analytical and experimental; applied research for a Master's degree.
(*e*) An orifice may be installed in catchbasin structures to alleviate possible surcharge in stormsewer systems. This study will investigate the performance of a simple choking device.

424-11353-370-90

HYDRAULIC MODEL INVESTIGATION OF A CULVERT JUNCTION STRUCTURE FOR IMPROVED OUTLET PERFORMANCE

(*b*) National Research Council of Canada.
(*c*) Professor D. R. Townsend.
(*d*) Experimental; applied research for a Master's degree.
(*e*) This laboratory study will investigate the effect of different outlet geometries on the hydraulic performance of box culverts when discharging supercritical flows.

422-11354-300-00

VARIATION IN RIVER BED ARMOURNIG DUE TO SEDIMENT CHARACTERISTICS

(*c*) Professor Eric J. Schiller.
(*d*) Experimental; basic research; M.A.Sc. thesis.
(*e*) The objective of this research project is to identify ways in which sediments carried through a channel by an armour-producing flow of water may influence parameters characterizing the armoured bed finally formed. The project consists of an investigation of armour variation as related to particle size of a sediment input. To this end a series of experimental runs were conducted with armouring produced under conditions wherein sediments of various particle sizes are carried by water flows.

422-11355-870-90

INLET AND OUTLET BAFFLING IN SEDIMENTATION BASINS

(*c*) Dr. R. L. Droste.
(*d*) Experimental; applied research; M.Eng. thesis.
(*e*) Various baffling configurations are being examined for their effects on hydraulic performance of a sedimentation basin. Dye tracers are being employed to monitor the flow through characteristics. Dispersion and dead space will be analyzed and compared for different baffle configurations and outlet conditions at different overflow rates. Suspended solids removal efficiency will then be compared to the hydraulic performance.
(*f*) Investigation in progess.

QUEEN'S UNIVERSITY, Department of Civil Engineering, Kingston, Canada K7L 3N6. H. M. Edwards, Professor and Head.

423-10515-370-90

BLOCKAGE, PLUG FLOW AND SLIDING BEDS IN PIPELINES TRANSPORTING SOLIDS

(*b*) National Research Council of Canada.
(*c*) Dr. K. C. Wilson
(*d*) Experimental and theoretical project.
(*e*) This topic is directly associated with design problems which occur in pipelines used industrially for transporting solids. A mathematical model of the phenomena being investigated has been proposed. Experimental investigations will be combined with further analytical work on the model.
(*f*) Investigation completed; results incorporated into analytic model.
(*h*) **Slip Model Correlation of Dense Two-Phase Flow,** K. C. Wilson, *Proc. 2nd Intl. Conf. Hydraulic Transport of Solids in Pipes*, BHRA Fluid Engrg., 1972.
Co-Ordinates for the Limit of Deposition in Pipeline Flow, K. C. Wilson, *Proc. 3rd Intl. Conf. Hydraulic Transport of Solids in Pipes*, BHRA Fluid Engrg., 1974.
Stationary Deposits and Sliding Beds in Pipes Transporting Solids, K. C. Wilson, *Proc. 1st Intl. Symp. Dredging Technology*, BHRA Fluid Engrg., 1975.

423-10516-130-90

ENTRAINMENT OF SOLID PARTICLES BY TURBULENT SUSPENSION

(*b*) National Research Council of Canada.
(*c*) Dr. K. C. Wilson.
(*d*) Theoretical (M.Sc. thesis), basic research.
(*e*) The efficiency of solids pipelining is directly linked to effective turbulent suspension. The present work accounts for the effect of the particle size relative to the scale of turbulence. Theoretical advances on the suspension of particles with various grading curves are underway.
(*h*) **Influence of Particle Diameter on the Turbulent Support of Solids in Pipeline Flow,** K. C. Wilson, W. E. Watt, *Proc. 3rd Intl. Conf. Hydraulic Transport of Solids in Pipes*, BHRA Fluid Engrg., 1974.

423-10517-370-90

UNIFIED ANALYTIC MODEL FOR SOLID-LIQUID PIPELINE FLOW

(*b*) National Research Council of Canada.
(*c*) Dr. K. C. Wilson.
(*d*) Theoretical and experimental, basic research.
(*e*) Results from the previous projects on deposition and turbulent entrainment are combined into a unified analytical model. Comparison with pilot plant and prototype data shows high success in the predictions of the analytic model.
(*h*) **A Unified Physically-Based Analysis of Solid-Liquid Pipeline Flow,** K. C. Wilson, *Proc. 4th Intl. Conf. Hydraulic Transport of Solids in Pipes*, BHRA Fluid Engrg., 1976.
New Techniques for the Scale-Up of Pilot-Plant Results to Coal Slurry Pipelines, K. C. Wilson, D. G. Judge, *Proc. Intl. Symp. Freight Pipeline*, Washington, D.C., 1976.
Application of Analytic Model to Stationary-Deposit Limit in Sand-Water Slurries, K. C. Wilson, D. G. Judge, *Proc. 2nd Intl. Symp. Dredging Technology, BHRA Fluid Engrg.*, 1977.
Analytically-Based Nomographic Charts for Sand-Water Flow, K. C. Wilson, D. G. Judge, *Proc. 5th Intl. Conf. Hydraulic Transport of Solids in Pipes, BHRA Fluid Engrg.*, 1978.

423-10518-810-00

ECONOMIC APPROACH TO OPTIMIZING DESIGN PARAMETERS

(*c*) Dr. K. C. Wilson, Dr. W. E. Watt.
(*d*) Theoretical (M.Sc. thesis), basic research.
(*e*) In the absence of uncertainty, the best design could be determined by economic optimization. It is found that the uncertainty inherent in the real-world use generally requires a shift in the design optimum. The magnitude of the shift and the cost associated with uncertainty are expressed as functions of the uncertainty in the input data.
(*h*) **Allowance for Risk and Uncertainty in the Optimal Design of Hydraulic Structures,** W. E. Watt, K. C. Wilson, *Proc. Intl. Symp. on Risk and Reliability in Water Resources*, pp. 575-591, 1978.

423-10519-000-90

MEASUREMENT OF THE FLUCTUATING VELOCITIES OF TURBULENCE IN A CIRCULAR COUETTE FLOW

(*b*) National Research Council of Canada.
(*c*) Dr. M. S. Yalin.
(*d*) Theoretical and experimental. Basic research, carried out by Dr. T. Tarimcioglu (Post Doctoral Fellow).
(*e*) The Couette flow is generated by two coaxial cylinders; speed variable, flow boundaries smooth. The root mean square values of all three fluctuating velocity components u'_r, u'_w, u'_z are measured as functions of the position (r,z). The measurements are carried out with the aid of a laser Doppler anemometer. Fluid is water, various values of the Reynolds number are achieved by varying the angular velocity τ and thus the relative linear velocity $\tau . R_1$. The distribution of the cross-correlation coefficients v_{ij} is also being determined.
(*f*) Completed.
(*h*) **Fluctuating Properties of Turbulence in a Circular Couette Flow,** *Proc. 5th Biannual Symp. Turbulence*, Univ. of Missouri-Rolla, 1977.

423-10520-200-90

THE INFLUENCE OF CONCENTRATION OF SUSPENDED SEDIMENT ON THE FLUCTUATING AND THE AVERAGE VELOCITIES OF TURBULENCE IN AN OPEN CHANNEL

(*b*) National Research Council of Canada.
(*c*) Dr. M. S. Yalin.
(*d*) Theoretical and experimental (M.Sc. thesis), basic research.
(*e*) The contemporary approach rests on the assumption that the presence of suspended load alters the value of the Von Karman constant, without affecting the logarithmic form of the distribution of time average velocities. It appears that this may be so in the special case of a uniformly distributed sediment concentration. It is intended to reveal how the logarithmic form is affected depending on the nonuniformity degree (dC/dy) of the concentration distribution $C = f(y)$. The analogous case will be investigated for the root mean square values of the fluctuating velocities u_i'.
(*f*) Completed.
(*h*) **On the Velocity Distribution of the Flow Carrying Sediment in Suspension,** M. S. Yalin, *Sedimentation (symposium to honor H. A. Einstein)*, Chap. 8, Fort Collins, Colo., U.S.A., 1972.

423-10521-220-90

ON THE TIME GROWTH OF DUNES FORMED BY A TURBULENT OPEN CHANNEL FLOW

(*b*) National Research Council of Canada.
(*c*) Dr. M. S. Yalin.
(*d*) Mainly experimental (M.Sc. thesis); basic research.
(*e*) It takes a certain duration (T) for dunes to grow to their fully developed size, starting from the flat initial sand bed (newly dredged bed of a river). The aim of the present measurements is to reveal how the "duration of development" T varies as a function of the parameters determining the flow and the bed material. An auxilliary objective is to reveal the manner of growth of the dune size λ with the time t (i.e., the form of $\lambda = f(t)$ for $0 < t < T$). The bed topography is measured with the aid of an electronic bed plotter.
(*f*) Completed.
(*h*) **On the Time-Growth of Dunes,** C. T. Bishop, *M.Sc. Thesis*, Queen's University, Kingston, Canada, 1977.
On the Development of Sand Waves in Time, M. S. Yalin, *Proc. XVI Congress of the Intl. Assoc. Hydraulic Research*, Sao Paulo, Brazil, 1975.
On the Physical Modeling of Dunes, M. S. Yalin, C. T. Bishop, *Proc. XVII Congress of the Intl. Assoc. Hydraulic Research*, Baden Baden, W. Germany, 1977.

423-10522-220-90

ON THE TIME GROWTH OF RIPPLES FORMED BY AN OPEN CHANNEL FLOW

(*b*) National Research Council of Canada.
(*c*) Dr. M. S. Yalin.
(*d*) Mainly experimental (M.Sc. thesis); basic research.
(*e*) Completely analogous to the preceding topic. The difference is that sand waves were ripples (which are almost independent of the flow depth) rather than dunes (which vary almost in proportion to flow depth).
(*f*) Completed.
(*h*) **On the Development of Ripples by an Open Channel Flow,** A. T. K. Fok, *M.Sc. Thesis*, Queen's University, Kingston, Canada, 1975.

423-10523-220-90

FORCES ACTING ON THE BED FEATURES OF AN OPEN CHANNEL FLOW

(*b*) National Research Council of Canada.
(*c*) Dr. M. S. Yalin.
(*d*) Mainly experimental (M.Sc. thesis); basic research.
(*e*) A shear plate was constructed for a direct measurement of the fluid dynamic forces acting on the (rigid) bed features simulating the sand waves (ripples or dunes). Thus the longitudinal magnitude of this force and consequently the overall bed shear stress and the friction factor was obtained. These quantities were determined as certain (experimental) functions of the relative size of bed features, their steepness and the roughness of their surface.
(*f*) Completed.
(*h*) **Forces Acting on the Bed Features of an Open Channel Flow,** S. Vatagodakumbura, *M.Sc. Thesis*, Queen's University, Kingston, Canada.

423-10524-220-90

ON THE DISTRIBUTION OF SUSPENDED SEDIMENT IN TRANSITIONAL REGIONS

(*b*) National Research Council of Canada.
(*c*) Dr. M. S. Yalin.
(*d*) Theoretical and experimental (Ph.D. thesis); basic research.
(*e*) Consider a clear fluid entering a cohesionless mobile bed. As a result of the dynamic action of flow the suspended load will grow (from "zero" onwards) along the direction of flow in a manner analogous to the growth of the boundary layer thickness. A reverse process (the settlement of the existing suspended load) will take place after the abrupt termination of the mobile bed. The purpose of this investigation was to determine the variation of the "ceiling" of concentration distribution in the flow direction (x) for both of the cases mentioned. A laser-beam technique was used to measure the concentration profiles (in the glass walled laboratory flume).
(*f*) Completed.
(*h*) **On the Development of the Distribution of Suspended Load,** M. S. Yalin, G. D. Finlayson, *Proc. XV Congress of the Intl. Assoc. Hydraulic Research*, Istanbul, Turkey, 1973.

423-10526-810-90

QUURM–QUEEN'S UNIVERSITY URBAN RUNOFF MODEL

(*b*) The National Research Council of Canada.
(*c*) Dr. W. Edgar Watt.
(*d*) Theoretical and field investigation towards M.Sc. degree.
(*e*) Calvin Park Urban Drainage Basin has been instrumented for rainfall, discharge and water quality. The Queen's University Urban Runoff Model (QUURM) has been developed and tested on a number of urban drainage basins in the simulation mode.
(*h*) **QUURM–A Realistic Urban Runoff Model,** W. E. Watt, C. H. R. Kidd, *J. Hydrology* **27**, pp. 225-235, 1975.
Hydrologic Effects of Urban Development, *Proc. Canadian Hydrology Symp. 75*, Natl. Research Council of Canada, pp. 708-717, 1975.

QUURM-Implications for the Design of Urban Drainage Basins, *Environmental Aspects of Irrigation and Drainage*, ASCE, pp. 580-592, 1976.

423-10528-410-90

DYNAMIC EQUILIBRIUM PROFILES

(*b*) National Research Council.
(*c*) Dr. J. W. Kamphuis.
(*d*) Experimental and theoretical research toward M.Sc. and Ph.D. degrees.
(*e*) Dynamic equilibrium profiles resulting from simulated annual wave climates are studied. The work encompasses beach profiles as well as rubble mound breakwater profiles.
(*h*) **Placing Artificial Beach Nourishment,** J. W. Kamphuis, S. G. Bridgeman, *Civil Engrg. in the Oceans III*, pp. 197-216, Delaware, 1975.
Three Dimensional Tests on Dynamic Equilibrium and Artificial Nourishment, *Proc. 15th Conf. Coastal Engrg.*, Honolulu, 1976.

423-10529-410-90

ARTIFICIAL BEACH NOURISHMENT

(*b*) National Research Council.
(*c*) Dr. J. W. Kamphuis.
(*d*) Experimental and theoretical research toward M.Sc. and Ph.D. degrees.
(*e*) Time and location of placement of artificial beach nourishment has been studied for both regular and irregular wave conditions. Effects of structures will be investigated.

423-10531-470-90

MARINA AGITATION

(*b*) National Research Council.
(*c*) Dr. J. W. Kamphuis.
(*d*) Experimental and theoretical research toward M.Sc. and Ph.D. degrees.
(*e*) Short wave agitation of marinas is studied. The forcing function (wave action outside and entrance conditions), as well as the responding function (marina configuration, perimeter protection, arrangement of docks and piers, placement of boats, etc.), are studied individually and in combination.
(*h*) **Hydraulic Design of Small Craft Harbours,** J. W. Kamphuis, *Proc. Conf. Coastal Engrg.*, Canadian Soc. for Civil Engrg., Kingston, 1979.

423-11687-410-90

BED FORMS IN OSCILLATORY FLOW

(*b*) National Research Council.
(*c*) Dr. A. Brebner.
(*d*) Basic research.
(*e*) Bed forms produced by oscillatory motion at the bed of the ocean are under investigation in 0.1 mm sand with wave periods from 3 to 135. The work is carried out in a large oscillating water tunnel.

423-11688-430-90

STABILITY OF RUBBLE FOUNDATIONS FOR CAISSON TYPE VERTICAL BREAKWATERS

(*b*) National Research Council.
(*c*) Dr. A. Brebner.
(*d*) Applied research.
(*e*) The stability under wave attack of a random nature of the rubble mound on which sits a vertical-walled caisson is being investigated. For deep water mooring such a system is the most economical. It can also be used for artificial islands on which drilling for oil or gas is taking place.

423-11689-220-90

ON THE GEOMETRY OF SAND WAVES FORMING ON RIVER BED

(*b*) National Research Council of Canada.
(*c*) Dr. M. S. Yalin.
(*d*) Theoretical and experimental.
(*e*) The occurrence of sand waves (ripples and dunes) on the surface of the river bed alters the "bed roughness" and exerts a marked influence on the mechanical structure of river flow. Clearly this influence can be predicted only if the geometry of sand waves is known. Yet at present the knowledge on the sand waves geometry is very vague and insufficient: hence the present research.
(*f*) Completed for dunes (with E. Karahan, post doctoral fellow), still active for ripples (M.Sc. thesis of L. Alexander).
(*h*) See the results obtained for dunes in: **On the Steepness of Sedimentary Dunes,** M. S. Yalin, E. Karahan, *J. Hydr. Div., Proc. ASCE* **105**, HY4, Apr. 1979.

423-11690-220-90

ON THE INCEPTION OF SEDIMENT TRANSPORT

(*b*) National Research Council of Canada.
(*c*) Dr. M. S. Yalin.
(*d*) Theoretical and experimental.
(*e*) It appears that the classical Shields' curve for determining the critical bed shear stress corresponding to the initiation of sediment transport is valid only for turbulent flows. And even in this case it is incorrect in the region of small values of the grain size Reynolds number. The purpose of the present research is to reveal the more realistic approach for the prediction of the inception of transport.
(*f*) Completed.
(*h*) **Inception of Sediment transport,** M. S. Yalin, E. Karahan, *J. Hydr. Div., Proc. ASCE.*

423-11691-200-90

CHARACTERISTICS OF TURBULENCE IN AN OPEN CHANNEL FLOW

(*b*) National Research Council of Canada.
(*c*) Dr. M. S. Yalin.
(*d*) Theoretical and experimental; basic research.
(*e*) Although the internal structure of turbulence for steady state parallel flows in closed conduits is sufficiently explored, the analogous information for the case of open channels (which are predominant in the civil engineering practice) is rather meagre. The purpose of the present research is to contribute to this end.
(*f*) Partly completed, still active: The measurements within the boundary layer of an open channel flow are in progress with Dr. E. Karahan, post doctoral fellow, Istanbul.
(*h*) **Laser-Doppler Anemometry Measurements in a Free Surface Flow,** P. J. Rae, M.Sc. Thesis, Queen's Univ., Kingston, Canada, 1978.

423-11692-870-90

INVESTIGATIONS OF HYDROCYCLONES

(*b*) National Research Council.
(*c*) Dr. J. D. Boadway.
(*d*) Basic research and development.
(*e*) The project is to develop a design of fluid cyclone suitable for making efficient separation of fine solids from liquids, such as in Sewage Treatment with a low pressure drop.

423-11693-300-90

REAL-TIME STREAMFLOW FORECASTING

(*b*) The National Research Council of Canada.
(*c*) Dr. W. Edgar Watt.
(*d*) Theoretical investigation; basic and applied research for M.Sc. and Ph.D. degrees.
(*e*) Deterministic and time series models have been calibrated for use in real-time streamflow forecasting. Work is continuing on the development of an effective updating technique.

(*h*) **Real-Time Spring Flood Forecasting for Intermediate Headwater Basins in Canada,** W. E. Watt, M. J. Nozdryn-Plotnicki, *Proc. Canadian Hydrology Symp.* **79,** NRCC, 1979.

423-11694-350-10

CALIBRATION OF SPILLWAYS IN THE PRESENCE OF AN ICE COVER

(*b*) U.S. Corps of Engineers.
(*c*) Professor S. S. Lazier.
(*d*) Experimental investigation; applied research; Master's thesis.
(*e*) The effect of an ice cover on the calibration of various types of spillways used in small dams is being studied in the laboratory using polyethylene sheets to simulate ice. Spillways to be tested include OGEE, Stoplog Sluice Gate, and rollway types with and without piers. The effect of roughness of ice will be investigated.
(*g*) Project just underway, but preliminary results indicate the effect may be positive or negative depending on location of downstream edge of ice cover.

423-11695-410-90

SEDIMENT TRANSPORT UNDER WAVE ACTION

(*b*) National Research Council.
(*c*) Dr. J. W. Kamphuis.
(*d*) Experimental and theoretical research toward M.Sc. degrees.
(*e*) Determination of sediment transport rates under regular and irregular wave action.
(*h*) **A Model Study of Alongshore Sediment Transport Rate,** J. W. Kamphuis, J. S. Readshaw, *Proc. Coastal Engrg. Conf.*, Hamburg, 1978.

UNIVERSITY OF REGINA, Regional Systems Engineering, Regina, Saskatchewan, Canada S4S 0A2. Dr. Gerald Fuller, Co-ordinator Regional Systems Engineering and Professor of Systems Engineering.

424-11356-300-00

GENERATION OF UNGAUGED STREAMFLOW DATA

(*c*) Dr. Gerald Fuller, Faculty of Engineering..
(*d*) Theoretical project; applied research.
(*e*) The project is devoted to developing a simple method of estimating streamflow data for an ungauged river from nearby streamflow records.
(*g*) Least squares models have been developed which can be used for estimating ungauged rivers. Study is continuing on effects of interdependency of streamflow predictor variables.
Inconsistent Matrices in Estimating Ungauged Streams, G. A. Fuller, *Water Resources Research* **10,** 6, 1249-1250, 1974.
Generation of Ungauged Streamflow Data, G. A. Fuller, *J. Hydraulics Div., ASCE* **104,** HY3, 377-384, 1978.

UNIVERSITY OF SASKATCHEWAN, Department of Civil Engineering, Hydraulics Laboratory, Saskatoon, Saskatchewan, Canada. Professor C. D. Smith, Department Head.

425-11357-370-90

LOW LEVEL RIVER CROSSINGS

(*b*) Department of Highways and Transportation.
(*d*) Experimental applied research.
(*e*) A model study was conducted to determine performance of a proposed low level river crossing for the North Saskatchewan River. The crossing, intended to replace a ferry, would consist of a low grade with many culverts, and would be overtopped during high flows.
(*f*) Completed.
(*g*) Performance was determined for water and ice flow during spring breakup. It was found that ice jamming would probably occur in most years.
(*h*) **Model Study of a Low Level River Crossing,** C. D. Smith, L. J. Hamblin, *Proc. Water Studies Inst. Symp.*, Saskatoon, May 1978.

425-11358-360-90

EFFECT OF WINGWALLS ON SCOUR BELOW A SUBMERGED ROLLER BUCKET

(*b*) National Research Council.
(*d*) Experimental basic research.
(*e*) A study of the effect of the shape and orientation of wingwalls on the scour downstream from a submerger roller bucket energy dissipator.
(*f*) Completed.
(*g*) It was found that wingwalls had a significant effect on performance, and design recommendations were made.
(*h*) **Effect of Wingwalls on Scour Below a Roller Bucket Energy Dissipator,** C. D. Smith, *Proc. 4th Natl. Hydrotechnical Conf.*, Vancouver, May 1979.

425-11359-220-90

SCOUR PROTECTION BELOW OVERHANGING CULVERTS

(*b*) National Research Council.
(*c*) Professor C. D. Smith.
(*d*) Experimental basic research for M.Sc. thesis.
(*e*) The nature of scour downstream from a projecting overhanging culvert was studied in order to determine the size and extent of riprap protection. The variables in the study were pipe diameter, discharge, drop height, tailwater depth, stone size and cantilever length.
(*g*) Design criteria are being established.

425-11360-210-90

HEAD RECOVERY DOWNSTREAM FROM CONDUIT OUTLETS

(*b*) National Research Council.
(*c*) Professor C. D. Smith.
(*d*) Experimental basic research for M.Sc. thesis.
(*e*) Study of conversion of outlet velocity head to elevation head in the channel downstream from a pipe outlet. Neglect of this head recovery results in calculated upstream water levels greater than actual, and can be important in certain situations.
(*g*) Recoveries up to 60 percent of the velocity head have been observed in some cases.

425-11361-220-90

SCOUR AROUND PILE-BENT BRIDGE PIERS

(*b*) National Research Council.
(*c*) Professor J. M. Wigham.
(*d*) Experimental, applied research for Masters thesis.
(*e*) Model tests have been conducted to determine scour depths, for a variety of flow conditions, around cylinder groupings representing pile-bent piers.

UNIVERSITY OF SASKATCHEWAN, Department of Mechanical Engineering, Saskatoon, Saskatchewan, Canada S7N OWO. Dr. P. R. Ukrainetz, Department Head.

THE EFFECT OF SHOCK WAVE INTERACTION WITH AN ATOMIZED LIQUID JET

426-07895-130-00

(*c*) M. E. Stoneham, Professor.
(*d*) Experimental, applied research.
(*e*) The mechanism of interaction of a shock wave with individual droplets and the effects upon droplet breakup that arise from the proximity of one droplet to another in one-dimensional arrays of droplets has been studied. The work

has been undertaken as the first phase of a programme of investigation with the ultimate objective of determining the effects of shock waves on the breakup times and droplet sizes and droplet distributions in atomized liquid jets.

(*g*) Measurement of the breakup times of droplets in equally-spaced one-dimensional droplet arrays at pitches less than 3.0 times droplet diameter and subject to transverse shock waves indicate that significant reduction in breakup times may be expected compared with estimates given by models for single droplets.

(*h*) **The Aerodynamic Breakup of Droplets in an Array,** M. E. Stoneham, G. Raghavan, *Proc. Combustion Inst. Tech. Mtg.*, Banff, 1977.

426-10332-810-90

THERMODYNAMICS OF SNOWMELT

(*b*) NRCC, IWD/DOE, Canada.

(*c*) D. H. Male, Professor.

(*d*) Field investigation, applied research.

(*e*) Define as precisely as practicable the various climatological and topographical factors which influence the movement of water through snow and ice in a prairie environment. The first phase of this work is an investigation of the thermodynamics of snowmelt designed to establish the relative importance of the evaporation, convection and radiation energy fluxes to the melt process for the range of climatological conditions normally encountered during the spring melt season. This phase is complete. The second phase of this work involves a study of melt rates when the snow cover is no longer continuous and bare patches appear. Major runoff events normally occur during this period and an attempt is being made to quantify the areal variability of melt rates under this condition.

(*h*) **Melting of a Prairie Snowpack,** R. J. Granger, D. H. Male, *J. App. Meteorol.* **17,** 12, pp. 1833-1842, 1978.

UNIVERSITE DE SHERBROOKE, Department of Civil Engineering, Faculty of Applied Science, Sherbrooke, Quebec, Canada J1K 2R1.

427-11369-220-00

ACTIVATION OF SEDIMENT TRANSPORT BY SHORT-CRESTED WAVES IN CHANNELS

(*c*) Dr. B. Gallez, Professeur titulaire, Département de génie civil, Faculté des Sciences appliquées, Université de Sherbrooke.

(*d*) Theoretical and experimental approach. Applied research with perspective of development.

(*e*) Title self-explanatory–Specifically, are investigated: kinematics and dynamics of short-crested waves on current in channels–critical bed shear–capacity of sediment transport–practicability and energy costs of operation.

(*g*) Generation of waves and fine control of their characteristics are completed–rate of sediment transport is clearly increased.

(*h*) **Short-Crested Waves on Channel Flows,** B. Gallez, *Tech. Report*, Département de génie civil, 1979.

427-11370-830-90

SOME ASPECTS OF SURFACE EROSION OF COHESIVE SOILS AND POSSIBILITIES OF MODELING

(*b*) National Research Council.

(*c*) Dr. K. Rohan, Département de génie civil, Faculté des Sciences appliquées, Université de Sherbrooke.

(*d*) Experimental-theoretical; basic and applied research, basis for Doctoral thesis.

(*e*) To qualify the erodibility of saturated cohesive soils from areas of water resources management and development.

(*g*) Preparation of samples and experimental equipment completed.

(*h*) Technical report–first part will be available in February 1980.

427-11371-300-90

IDENTIFICATION OF RIVER MODELS

(*b*) CNRC.

(*c*) Dr. P. E. Brunelle, Département de génie civil, Faculté des Sciences applieqées, Université de Sherbrooke.

(*d*) Theoretical and simulated approach for eventual use in optimal control of resource systems.

(*e*) Transfer function from input-output, by adaptive correlation techniques. Relations between coefficients and physical parameters.

(*g*) Techniques for transformation of impulse response to transfer function and inverse completed. Fast adaptive identification scheme developed.

(*h*) T4-4-8 Technical report: HB1N Impulse Response and Transformation. T5-12-8 Technical report: Adaptive Identification.

427-11372-800-90

RESOURCES SYSTEM OPTIMIZATION

(*b*) National Research Council of Canada.

(*c*) Dr. P. E. Brunelle, D épartement de génie civil, Faculté des Sciences appliquées, Université de Sherbrooke.

(*d*) Numerical M.Sc.A. project.

(*e*) Computer treatment of optimal siting and sizing of resource systems by branch and bound techniques, as well as operation optimization.

(*f*) Nearing completion.

(*g*) Network representation of system using compact list structure complete. Optimizing algorithms operational.

(*h*) Masters thesis to be submitted in Fall 79.

UNIVERSITY OF TORONTO, Department of Chemical Engineering and Applied Chemistry, Toronto, Ontario, Canada, M5S 1A4. Professor M. E. Charles, Chairman.

428-06950-050-00

IMPINGING JET STUDIES

(*c*) Dr. Olev Trass, Professor.

(*d*) Experimental and theoretical studies for graduate theses, basic research.

(*e*) Velocity profiles, turbulence and boundary layer development for liquid and gas jets impinging on flat surfaces. Pressure distributions and local mass transfer rates at the surface. Application to heat and mass transfer situations of academic as well as industrial interest.

(*f*) Main aspects completed.

(*g*) Theoretical solutions and experimental verification of flow, turbulence and wall mass transfer. General impingement region characterization model proposed. Initial study of mechanical erosion with and without diffusional mass transfer completed.

(*h*) **Mass Transfer from Crystalline Surfaces in a Turbulent Impinging Jet. Part I. Transfer by Erosion,** F. Giralt, O. Trass, *Can. Jour. of Chem. Eng.* **53,** pp. 505-511, 1975.
Mass Transfer from Crystalline Surfaces in a Turbulent Impinging Jet. Part II. Erosion and Diffusional Transfer, F. Giralt, O. Trass, *Can. Jour. Chem. Eng.* **54,** pp. 148-155, 1976.
Characterization of the Impingement Region in an Axisymmetric Turbulent Jet, F. Giralt, C. J. Chia, O. Trass, *Ind. Eng. Chem. Fundam.* **16,** 1, pp. 21-28, 1977.
Mass Transfer in Axisymmetric Turbulent Impinging Jets, C. J. Chia, F. Giralt, O. Trass, *Ind. Eng. Chem. Fundam.* **16,** 1, pp. 28-35, 1977.

428-06951-140-00

ROUGH SURFACE TRANSFER

(*c*) Dr. Olev Trass, Professor.

(*d*) Mainly experimental studies for graduate theses, basic research.

(*e*) Flow patterns and mass transfer at surfaces having various types and sizes of roughness. To elucidate influence of roughness patterns on momentum, heat and mass transfer.
(*g*) Some mass transfer results for random and regular V-groove roughnesses. Initial characterization of irregular surface roughness patterns.
(*h*) **Mass Transfer at Rough Surfaces,** D. A. Dawson, O. Trass, *Intl. J. Heat Mass Transfer* **15,** pp. 1317-1336, 1972.

428-06952-710-00

FLOW VISUALIZATION STUDIES BY PHOTOCHROMIC DYE TECHNIQUE

(*c*) R. L. Hummel, Professor.
(*d*) Experimental, basic and applied research, for Ph.D., M.A.Sc., postdoctorals and technical assistants.
(*e*) The technique uses a dye indicator, for example 2-(2'4'-dinitrobenzyl) pyridine, which is converted from an almost colourless form to one which is deep blue by a beamed ultraviolet light. The light is generated by lasers, flash lamps, etc., in a collimated beam which can generate dye lines. The dye lines are followed photographically, and properties of the flow, such as velocity profiles are measured. The high speed automatic flow visualization computer "POLLY," is used to log and analyse the data.
(*h*) **Fluid Velocity Profiles Near the Wall of Liquid-Fluidized Beds,** B. G. Allen, J. W. Smith, *Can. J. Chem. Eng.* **41,** pp. 430-438, 1971.
Some Statistical Properties of Turbulent Momentum Transfer in Rough Pipes, S. G. Dunn, J. W. Smith, *Can. J. Chem. Eng.* **50,** pp. 561-568, 1972.
An Experimental Study of Instabilities and Other Flow Properties of a Laminar Pipe Jet, A. De P. Iribarne, F. Frantisak, R. L. Hummel, J. W. Smith, *AIChE J.* **18,** pp. 689-698, 1972.
Studies of Fluid Flow by Photography Using a Non-Disturbing Light-Sensitive Indicator, J. W. Smith, R. L. Hummel, *J. SMPTE* **82,** pp. 278-281, 1973.
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Determination of the Position of Visualized Material Elements in Growing Drops, J. A. C. Humphrey, R. L. Hummel, J. W. Smith, *Can. J. Chem. Eng.* **52,** pp. 110-113, 1974.
Mass Transfer Enhancement Due to Circulation in Growing Drops, J. A. C. Humphrey, R. L. Hummel, J. W. Smith, *Chem. Eng. Sci.* **29,** pp. 1496-1500, 1974.
Experimental Profiles in Laminar Flow Around Spheres at Intermediate Reynolds Number, L. E. Seeley, R. L. Hummel, J. W. Smith, *J. Fluid Mech.* **68,** p. 591, Apr. 1975.
Experimental Study of the Fluid Dynamics of Forming Drops, J. A. C. Humphrey, R. L. Hummel, J. W. Smith, *Can. J. Chem. Eng.* **52,** pp. 449-456, 1974.
Laminar Flow in the Central Plane of a Curved Circular Pipe, J. Kaczinsky, J. W. Smith, R. L. Hummel, *Can. J. Chem. Eng.* **53,** pp. 221-224, 1975.
Some Observations of Wake Behaviour in Laminar and Turbulent Free Stream Flow, L. E. Seeley, R. L. Hummel, J. W. Smith, *Proc. 4th Biennial Symp. Turbulence in Liquids*, Univ. of Missouri-Rolla, Sept. 1975.

428-11362-370-90

HEAT TRANSFER STUDIES AFFECTING SUBMARINE GAS PIPELINING IN THE ARCTIC (No. 1)

START-UP CHARACTERISTICS OF GELLING-TYPE CRUDE OILS IN ARCTIC PIPELINES (No. 2)

(*b*) (1) Polar Gas Project and Natural Sciences and Engineering Research Council Canada.
(2)Panarctic Oil Ltd.
(*c*) Professor J. W. Smith.
(*d*) (1) An experimental and theoretical project to determine the nature and extent of ice formation and nucleation on submarine gas pipelines; applied research and design for master's theses and undergraduate student's projects.
(2)An experimental and theoretical study of freezing and start-up characteristics of gelling-type crude oils in pipelines.
(*e*) Heat transfer is a concern in submarine pipelining in the Arctic. Due to the adiabatic cooling of natural gas and to the Joule-Thomson effect, temperatures below the freezing point of sea water can readily be reached on long crossings. This study is a comprehensive evaluation of the effect of light currents on heat transfer rates from simulated pipelines resting on bottom sediments, the nucleation of ice and its steady-state form, and control technologies which may be applied.
(*f*) Active, with one full time master's student and part-time technical assistance. One B.A.Sc. thesis per session.
(*g*) Results have been submitted to the sponsors in the form of confidential reports. The correspondent will be pleased to discuss the results with competent authorities in the field.
(*h*) **Heat Transfer from Pipelines in Arctic Waters,** D. F. Cooper, J. W. Smith, 1976.
Heat Transfer Studies–Progress Report, C. D. Crawford, D. F. Cooper, J. W. Smith, Nov. 1978.
A Study of Factors Affecting Ice Formation on Natural Gas Pipelines in Arctic Waters, G. S. Locke for J. W. Smith, Apr. 1978.
Interim Report on Ice Growth on Submerged Pipelines, C. D. Crawford, D. F. Cooper, J. W. Smith, Jan. 1, 1978–Aug. 15, 1978.
Natural and Mixed Convective Heat Transfer from a Horizontal Cylinder, C. D. Crawford, J. W. Smith, *Summary of the B.A.Sc. Thesis by C. D. Crawford*, Aug. 1977.
Tests on the Effect of Proximity of the Cylinder to the Ice Layer for Natural Convection from a Horizontal Cylinder–Summer 1977, C. D. Crawford, J. W. Smith, Aug. 1977.
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Natural and Mixed Convective Heat Transfer from a Horizontal Cylinder, C. D. Crawford, *B.A.Sc. Thesis*, 1977.
A Study of Factors Affecting Ice Formation on Natural Gas Pipelines in Arctic Waters, G. S. Locke, *B.A.Sc. Thesis*, 1978.
Mixed Convective Heat Transfer to Gas Pipelines in Arctic Waters, A. Norval, *B.A.Sc. Thesis*, 1979.

UNIVERSITY OF TORONTO, Department of Mechanical Engineering, Toronto, Canada M5S 1A4. Professor David S. Scott, Department Chairman.

429-06817-360-90

TURBULENCE MEASUREMENTS IN WATER

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor H. J. Leutheusser.
(*d*) Experimental; basic research.
(*e*) Evaluation of turbulence parameters in hydraulic jump.
(*f*) Completed.
(*g*) Measurements of turbulence characteristics, air entrainment and flow separation reveal significant effects of condition of inflow onto flow inside jump body.
(*h*) **Flow Separation under Hydraulic Jump,** H. J. Leutheusser, S. Alemu, *J. Hydr. Research* **17,** 3, 1979.

429-07461-240-90

VORTEX-INDUCED OSCILLATIONS OF BLUFF CYLINDERS

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor I. G. Currie.

(*d*) Experimental, basic research (with applications) for Master's theses.
(*e*) To establish the pressure distribution around bluff cylinders which are subjected to vortex-induced oscillations. Also, to determine what differences, if any, exist between massive cylinders vibrating in light fluids (such as air) and light cylinders vibrating in heavy fluids (such as water).
(*g*) Pressure distributions have been recorded for a freely-oscillating cylinder and for forced oscillations of a cylinder. The response of cylinders of various masses is currently being investigated.
(*h*) **Pressure Fluctuation Measurements on an Oscillating Circular Cylinder,** P. W. Bearman, I. G. Currie, to be published in the *J. of Fluid Mechanics.*
Vortex-Induced Oscillations of a Circular Cylinder in Water, Y. H. Seeto, *M.A.Sc. Thesis,* Dept. of Mechanical Engrg., Univ. of Toronto, 1979.

429-07899-010-90

BOUNDARY LAYER SEPARATION ON BLUFF BODIES

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor I. G. Currie.
(*d*) Experimental and theoretical, basic research, for Ph.D. thesis.
(*e*) To establish the physics of a laminar separation point as exists on a bluff body at subcritical Reynolds numbers. Also, to advance the theory of such a flow.
(*g*) Pressure and velocity distributions have been recorded for a circular cylinder in water through the use of laser-Doppler anemometry.
(*h*) **Measurements Around a Laminar Separation Point,** R. L. Varty, I. G. Currie, *Proc. 7th Canadian Congress of Applied Mechanics,* 1979.

429-07903-020-90

INTERMITTENCY IN TURBULENT FLOWS

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor James F. Keffer.
(*d*) Basic research, experimental and theoretical.
(*e*) Continuing investigation of the properties of the turbulent/non-turbulent interface at the free edge of shear flows, e.g., boundary layers, wakes, jets and mixing layers. On-line digital sampling and processing techniques are used. Passive contaminants are used to help identify the turbulent field.
(*g*) Generalized method for deciding when fluid motion is turbulent has been studied. Improved detector functions have been derived as a result. Techniques have been applied to a turbulent boundary layer, thermal mixing layer, hot wake and hot jet.
(*h*) **Vortex Street Evolution in the Wake of a Circular Cylinder,** R. S. Budny, J. G. Kawall, J. F. Keffer, *Proc. 2nd Symp. Turb. Shear Flows,* London, 1979.
Interface Statistics of a Uniformly Distorted Heated Turbulent Wake, J. G. Kawall, J. F. Keffer, *Physics of Fluids* **22,** pp. 31-39, 1979.
Measurement of Spanwise Distribution of Turbulent Structures, J. F. Keffer, *Proc. Dynamic Flow Conference,* Baltimore, Marseille, 1978.
Digital Technique for Simultaneous Measurement of Velocity and Temperature, J. F. Keffer, R. S. Budny, J. G. Kawall, *Rev. Sci. Inst.* 49, pp. 1343-6, 1978.
Spanwise Structure of the Plane Turbulent Wake, M. L. Barsoum, J. G. Kawall, J. F. Keffer, *Physics of Fluids* **21,** pp. 157-161, 1978.

429-07904-480-90

WIND STRUCTURE OVER URBAN AREAS

(*c*) Professor James F. Keffer.
(*d*) Basic research, experimental and theoretical, field study.
(*e*) Digital sampling and processing of data taken from field stations are used to determine the large-scale structure of wind generated by large buildings. Field sites are chosen so that multi-point, spacetime correlation techniques can be used.
(*g*) Preliminary results show a shift of energy in power spectrum from high to low wave numbers.

429-09595-060-90

VERY LIGHT PLUMES

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor W. D. Baines.
(*d*) Experimental and theoretical.
(*e*) Buoyant plumes with very large differences of temperature relative to the surroundings are common in steel mills and any other industrial process where free combustion can occur. The rate of entrainment for any plume depends on both the velocity and density of the fluid but only the effect of velocity has been studied previously.
(*g*) Numerical solutions indicate that light plumes spread more slowly than plumes with small density differences. Experimental results obtained to date confirm the trend.
(*h*) **Non-Boussinesq Forced Plumes,** P. F. Crapper, W. D. Baines, *Atmos. Environ.* **11,** 415-420, 1977.
Some Remarks on Non-Boussinesq Forced Plumes, P. F. Crapper, W. D. Baines, *Atmos. Environ.* **12,** 1939-1941.

429-09597-020-90

SPREAD OF HEAT AND MOMENTUM IN ASYMMETRICAL TURBULENT FLOWS

(*b*) Natural Sciences and Engineering Research Council of Canada and I.M.S.T., Marseille, France.
(*c*) Professor James F. Keffer.
(*d*) Basic research, experimental and theoretical.
(*e*) Examination of spread of contaminants in free turbulent shear flows with asymmetrical velocity and temperature profiles. Experiments being carried out in mixing layer with jump in temperature and an asymmetrical, partially heated jet.
(*g*) It has been found for the velocity case of an asymmetric wake flow that a relatively large region of "negative production of turbulence" exists. For the case of a partially heated mixing layer the equivalent thermal situation is found also.
(*h*) **Analysis of Turbulent Structures In Complex Shear Flows,** J. F. Keffer, J. G. Kawall, F. Giralt, C. Béguier, *Proc. 2nd Symp. on Turb. Shear Flows,* London, 1979.
The Turbulent Mixing Layer with an Asymmetrical Distribution of Temperature, C. Béguier, L. Fulachier, J. F. Keffer, *J. Fluid Mech.* **89,** pp. 561-88, 1978.
Turbulent Heated Flows with Asymmetrical Mean Temperature Profiles, C. Béguer, F. Giralt, J. F. Keffer, *Proc. 6th Intl. Heat Transfer Congress,* Toronto, 1978.
Champ dynamique moyen en aval de deux cylindres identiques avec couplage initial faibie, C. Béguier, F. Giralt, J. F. Keffer, *Compt. Rendus B-243,* Mai 1978.
Negative Production In Turbulent Shear Flows, C. Béguier, F. Giralt, L. Fulachier, J. F. Keffer, *Proc. Symp. Struct. and Mech. of Turbulence,* Berlin, 1977.

429-09598-020-90

DISTORTION OF TURBULENT SHEAR FLOWS

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor James F. Keffer.
(*d*) Basic research, experimental and theoretical.
(*e*) Examination of gross uniform strain applied to various shear flows, e.g., wakes and mixing layers.
(*g*) Results for a thermal mixing layer indicate that the self-preserving scales do not follow the predicted variation.
(*h*) **The Uniform Distortion of Thermal and Velocity Mixing Layers,** J. F. Keffer, J. G. Kawall, J. C. R. Hunt, M. R. Maxey, *J. Fluid Mech.* **86,** 465-490, 1978.
Uniform Distortion of a Heated Turbulent Wake, J. G. Kawall, J. F. Keffer, *Proc. Symp. Struct. and Mech. of Turbulence,* Berlin, 1977.

429-09599-210-90

SKIN FRICTION IN UNSTEADY FLOW

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor H. J. Leutheusser.
(*d*) Basic research, experimental and theoretical.
(*e*) Study of the mechanics of energy dissipation in transient flow.
(*g*) U-tube oscillations and establishment-in-time of pipe flow have been studied both experimentally and analytically. Results indicate conclusively that the standard techniques for approximating transient skin friction effects lead to erroneous results.
(*h*) **Problems of Accelerated Fluid Motion,** H. J. Leutheusser, *Proc. Vol. 6, XVIIth Congress of IAHR*, Baden Baden, Germany, pp. 245-252, 1977.
Unified Approach to the Solution of Problems of Unsteady Laminar Flow in Long Pipes, M. F. Leterlier S. and H. J. Leutheusser, in *Fluid Transients and Acoustics in the Power Industry*, edited by C. Papadakis and H. Scarton, ASME, New York, pp. 207-213, 1978.

429-10502-000-90

PLANE COUETTE FLOW

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor H. J. Leutheusser.
(*d*) Experimental and theoretical, basic research.
(*e*) A fundamental investigation of the structure of turbulence in a uniformly sheared flow with and without wall roughness is being undertaken. The Couette principle will also be applied to a study of the initial steps in surface-wave generation by applying a known shear stress to a water surface.
(*g*) Novel experimental facility has been retrofitted to an existing towing tank installation and provides two rigid plates in straight-line motion relative to each other.
(*h*) **Very Low Velocity Calibration and Application of Hot-Wire Probes,** M. Aydin, H. J. Leutheusser, *DISA-Information*, in press.
Turbulence Characteristics in the Constant Stress Layer of Wall Shear Flows, M. Aydin, H. J. Leutheusser, *Proc. XVIIIth Congress of IAHR*, Cagliari, Sardinia, Italy, Sept. 1979.

429-10506-130-90

PRESSURE FLUCTUATIONS IN TWO-PHASE FLOW

(*b*) Natural Sciences and Engineering Research Council of Canada; Institut fuer Hydromechanik, Universitaet Karlsruhe, Germany.
(*c*) Professor H. J. Leutheusser.
(*d*) Experimental, basic research for Master's thesis.
(*e*) It is known that the occurrence of two-phase flow in hydraulic systems tends to render fluctuating forces more intense and regular. It is planned to study the fundamental physical processes involved in this transformation.
(*g*) From a detailed experimental study of bubbles rising in a quiescent liquid it appears that collisions may be the basic cause of transient pressures in two-phase flow.
(*h*) **Experimental Studies of Two-Phase Air-Water Flows,** H. J. Leutheusser, *Proc. Dynamic Flow Conference*, Johns Hopkins Univ., Baltimore, Md., Sept. 1978.

429-11363-420-90

GRAVITY SURGES ALONG HORIZONTAL SURFACES

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor W. D. Baines.
(*d*) Experimental and theoretical.
(*e*) A finite volume of liquid is released at the end of a two-dimensional canal which contains liquid which is either lighter or heavier. Experimental studies have so far been concentrated on surges of fresh water into salt water and vice-versa. Theoretical studies of the shape and speed of the surge indicate that predictions can also be made for immiscible fluids such as air bubbles moving over water in a pipe.
(*g*) Surges move with a constant velocity which is a function of its volume and the depth of the canal. In some cases the internal recirculation pattern provides a net inflow of canal fluid which dilutes the surge fluids.

429-11364-200-90

GRADUALLY VARIED LAMINAR FLOW IN OPEN CHANNELS

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor H. J. Leutheusser.
(*d*) Experimental and theoretical; basic research with important practical applications; Ph.D. thesis.
(*e*) Industrial melts (i.e., metals, glass, etc.) are conveyed routinely in long open channels from furnaces to forming machines. Flow is generally laminar at low Reynolds number and, thus, critically dependent upon shape of channel cross-section. Present research will provide much needed fundamental and design information on the phenomenon.

429-11365-210-90

INTERNAL OSCILLATIONS IN PIPE FLOWS

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor I.G. Currie.
(*d*) Experimental, basic research, for Master's thesis.
(*e*) To explore the mechanisms of internal oscillations which are sometimes observed and encountered in pipe flows and which are thought to be resonances excited by acoustic sources.

429-11366-030-90

THE EFFECT OF STREAMWISE OSCILLATIONS OF A CIRCULAR CYLINDER IN THE CRITICAL REYNOLDS NUMBER RANGE

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor W. W. Martin.
(*d*) Experimental, basic research.
(*e*) The effect of streamwise vibrations on the flow around a circular cylinder is being studied for the critical range of Reynolds number where boundary-layer reattachment occurs. The experiments are intended to discover whether a periodic interaction between the cylinder motion and the flow develops to produce a self-sustaining oscillation.
(*g*) Experiments on a fixed cylinder showed that there is a sudden change in Strouhal number when stable boundary-layer reattachment occurs. This is preceded by an intermittent condition which can become periodic when the cylinder oscillates at high enough frequency for a given amplitude. The fluctuations in the wake for this condition are observed to be predominantly at the cylinder frequency rather than the usual Strouhal frequency and alternate shedding is replaced by nearly simultaneous shedding.

429-11367-050-90

TURBULENT TRANSPORT IN FORCED PLUMES

(*b*) National Science and Engineering Research Council of Canada.
(*c*) Professors W. W. Martin and W. D. Baines.
(*d*) Experimental, basic research.
(*e*) Forced axisymmetric plumes are being studied using weak saltwater solutions. Velocity measurements are being made using LDA, and concentration is measured with a conductivity probe.
(*g*) Mean measurements show that the profiles are similar and well represented by Gaussian curves. In addition, linear spread is found for this intermediary flow as for pure jets and plumes.

429-11368-250-90

EXTENSIONAL FLOWS OF DRAG-REDUCING POLYMER SOLUTIONS

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor D. F. James.
(*d*) Experimental, theoretical, basic research.
(*e*) Dilute polymer solutions, in the drag-reducing regime, are studied in sink flow, a particular type of extensional flow. The experimental flow channel is conical in shape, and the streamlines are rays toward the apex. Measurements show an increased pressure drop in the channel, and an analysis of the flow reveals that the increase can be explained only by a fluid containing the equivalent of long fibres.

TRENT UNIVERSITY, Department of Geography, Peterborough, Ontario, Canada K9J 7B8. Dr. A. G. Brunger, Chairman.

431-10618-810-90

SNOWFALL AND SNOWCOVER IN THE PETERBOROUGH AREA

(*b*) Environment Canada.
(*c*) Dr. W. P. Adams.
(*d*) Field investigation.
(*e*) Studies of methods of measuring snowfall; areal distribution and stratigraphy of snowcover.
(*g*) Comparative data from Nipher, Wyoming and Trehakov snow gauges now available.
(*h*) **Areal Differentiation of Snowcover in East Central Ontario,** W. P. Adams, *Water Resources Res.* **12,** 6, pp. 1226-1234, 1976.
Limitations of the Bulk Density Method of Snow Course Measurement and the Need for More Detailed Snow Data, W. P. Adams, *J. of Soil and Water Conservation* **32,** 3, pp. 135-137.
The Climatological Record for Peterborough, *Occasional Paper No. 6,* Dept. of Geography, Trent University, 240 p., 1978.

431-10619-440-90

SNOW AND ICE COVER OF LAKES

(*b*) National Research Council of Canada, Environment Canada.
(*c*) Dr. W. P. Adams.
(*d*) Field investigation, includes graduate research.
(*e*) A study of the growth and decay of the winter cover of lakes with some reference to the biological roles of that cover.
(*g*) Current work includes study of alteration of light by snow and ice on lakes.
(*h*) **The Role of Ice and Snow in Lake Heat Budgets,** W. P. Adams, D. C. Lasenby, *Limnology and Oceanography* **23,** 5, 1025-1028, 1978.
Snow and Ice in the Phosphorous Budget of a Lake in South Central Ontario, W. P. Adams, M. C. English, D. C. Lasenby, *Water Research* **13,** pp. 210-215, 1978.
Observations and Special Characteristics of Lake Snowcover, W. P. Adams, T. D. Prowse, *Proc. Eastern Snow Conference* **35,** 1978 (in press).

431-10620-810-90

EFFECTS OF URBANIZATION ON STREAMFLOW, PETERBOROUGH, ONTARIO

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Dr. C. H. Taylor.
(*d*) Field investigation; M.Sc. thesis submitted (Roth).
(*e*) A study of the effects of on-going suburban development on the runoff response and sediment yield of a small stream in Peterborough, Ontario.
(*f*) The study has been on-going since 1973.
(*g*) Results indicate that suburban development has increased peak discharges and direct runoff volumes significantly, and that the magnitude of the effect varies seasonally.
(*h*) **Effects of Suburban Construction on Runoff Contributing Zones in a Small Southern Ontario Drainage Basin,** C. H. Taylor, D. M. Roth, *Hydrological Sciences Bull.,* 1979 (in press).
Changes in the Runoff Response of Kawartha Heights Stream Resulting from Urbanization, D. M. Roth, *M.Sc. Thesis,* Trent University, Peterborough, Ontario, 1979.

431-10621-810-90

RUNOFF PRODUCTION IN A SMALL SWAMP NEAR PETERBOROUGH, ONTARIO

(*b*) Natural Sciences and Engineering Research Council Canada.
(*c*) Dr. C. H. Taylor.
(*d*) Field investigation; M.Sc. thesis submitted, one in progress.
(*e*) This study is an investigation of the processes that control the runoff response of a small swamp-fed stream. Particular attention is being paid to the applicability of the variable source area model, by relating seasonal and storm-to-storm fluctuations in the extent of the saturated area to the runoff response. Both snowmelt and rainstorm events are included.
(*g*) Field data have been collected for three seasons and are currently being analysed. Preliminary indications are that fluctuations in swamp area, related to variations in the local water table, are the dominant control of the runoff response.
(*h*) **The Disposition of Precipitation by Vegetation on a Mixed Forested Watershed in the Kawartha Lakes Region of East Central Ontario,** T. J. Mathers, *M.Sc. Thesis,* Trent University, Peterborough, Ontario, 1979.

UNIVERSITY OF WATERLOO, Department of Mechanical Engineering, Waterloo, Ontario, Canada, N2L 3Gl. Professor D. J. Burns, Department Chairman.

432-11373-050-73

PREDICTION OF BUOYANT SURFACE DISCHARGES

(*b*) Ontario Hydro, Natural Sciences and Engineering Research Council of Canada.
(*c*) Professors G. D. Raithby, and G. E. Schneider.
(*d*) Theoretical: finite-difference solution of turbulent-flow model; applied research.
(*e*) Development of a model for the three-dimensional motion of a buoyant surface-discharge jet. The model has been verified using available laboratory, physical model and field data. Because the model is relatively inexpensive to run, and because the results are in quantitative agreement with measurement, it will eventually replace the need for some of the physical model experiments required for environmental impact assessment.
(*h*) **Prediction of Dispersion By Surface Discharge,** G. D. Raithby, *Canada Centre for Inland Waters Report,* Aug. 1976.
A Finite-Difference Model for the Prediction of Surface Discharges, Including Crossflow Effect, Ontario Hydro Dept., Feb. 1978.

432-11374-740-90

FINITE ELEMENT PREDICTION OF FLUID FLOWS

(*b*) Natural Sciences and Engineering Research Council Canada.
(*c*) G. E. Schneider.
(*d*) Theoretical, basic and applied.
(*e*) Examination of the basis of, and methods for surmounting the requirement for reduced order pressure interpolation. Also application of finite element methods to engineering problems.

(*h*) **Finite Element Analysis of Incompressible Fluid Flow Incorporating Equal Order Pressure and Velocity Interpolation,** G. E. Schneider, G. D. Raithby, M. M. Yovanovich, presented *1st Intl. Conf. Numerical Methods in Laminar and Turbulent Flow*, Wales, Swansea, July 17-21, 1978.

Finite Element Procedures for Solving the Incompressible Navier Stokes Equations Using Equal Order Variable Interpolation, G. E. Schneider, G. D. Raithby, M. M. Yovanovich, accepted for publication in *Numerical Heat Transfer*.

Fully Developed Heat Transfer in Passages of Triangular Cross-Section for Application to Solar Collector Plate Design, G. E. Schneider, B. L. LeDain, presented *AIAA Terrestial Energy Systems Conf.*, June 4-6, 1979, Orlando, Fla.

432-11375-050-73

FINITE DIFFERENCE PREDICTION OF TURBULENT, BUOYANT SURFACE DISCHARGES

(*b*) Ontario Hydro, Natural Sciences and Engineering Research Council of Canada.
(*c*) G. D. Raithby, G. E. Schneider.
(*d*) Applied analytical research with program development.
(*e*) Development of numerical prediction methods and modeling procedures for the prediction of buoyant, turbulent, surface discharges in quiescent or cross-flow ambient environments.
(*g*) Excellent agreement of numerical predictions with laboratory experimental results.
(*h*) **A Finite-Difference Model for the Prediction of Surface Discharges, Including Crossflow Effects,** G. E. Schneider, G. D. Raithby, *Final Report to Hydraulic Studies Dept. of Ontario Hydro*, Feb. 1, 1979.

The Prediction of Surface Discharge Jets by a Three-Dimensional Finite Difference Model, G. D. Raithby, G. E. Schneider, submitted to *ASME J. Heat Transfer*, Feb. 1979.

432-11376-020-90

TURBULENT SHEAR FLOWS

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) A. B. Strong, E. Brundrett.
(*d*) Experimental and theoretical, basic and applied.
(*e*) This work involves experimental measurements of near wall turbulence characteristics and development of higher order closures for turbulent flows with curvature and buoyancy effects.
(*h*) **Direct Measurement of Wall Shear Stress with Mass Transfer in a Low Speed Boundary Layer,** K. Depooter, E. Brundrett, A. B. Strong, *ASME J. Fluid Eng.* **99,** 3, pp. 580-584, 1977.

On the Laminar and Turbulent Taylor Vortex Flow in an Annular Passage with Axial Flow, R. A. Nickell, A. B. Strong, W. B. Nicoll, *Proc. 4th Braz. Cong. Mech. Eng. Paper No. B-10*, pp. 511-528, Florianopolis (1977). See also *Prog. Heat Mass Transfer*, D. B. Spalding (Ed). To be published 1979.

The Calibration of Preston Tubes in Transpired Turbulent Boundary Layers, K. Depooter, E. Brundrett, A. B. Strong, *ASME J. Fluids Eng.* **100,** 1, pp. 10-16, 1978.

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432-11377-130-90

THE FLUID MECHANICS OF DUSTS AND AEROSOLS

(*b*) Natural Sciences and Engineering Research Council of Canada; Ontario Ministry of Labour.
(*c*) Professor G. M. Bragg.
(*d*) Experimental and analytical.
(*e*) Basic flow mechanisms involved in the particulate measurement process are under study. Analytical models have been developed for the filtration process and for the conveyance of dust in ducts. A statistical study of dusts has been applied to dust control problems in the asbestos industry.
(*h*) **A Statistical Analysis of Asbestos Fibre Counting in the Laboratory and Industrial Environment,** G. Rajhans, G. Bragg, *Amer. Industrial Hygiene Assoc. J.* **36,** 1975.

Asbestos Exposures in Ontario–A Review, G. Rajhans, G. Bragg, I. Morton, *Occupational Health in Ontario* **29,** 1977.

Prediction of Transport Velocities of Dust in Horizontal Ducts, G. Bragg, M. Kwan, *Proc. Pneumotransport*, 1978 (pub. British Hydromechanics Research Association).

Particulate Diffusion Across a Plane Turbulent Jet, G. Bragg, H. Bednarik, *Intl. J. Heat and Mass Transfer* **18,** 1975.

432-11378-690-88

WIND POWER

(*b*) International Development Research Centre.
(*c*) Professor G. M. Bragg.
(*e*) Optimization studies have been undertaken for arrays of wind power machines and for design of windmill-water-pumping systems. Attention is directed to mutual interaction of wind mills and the atmospheric boundary layer and to basic aerodynamics of windmills. Applications appear in performance prediction of variable speed systems. Special emphasis is placed on applications in developing countries.
(*h*) **Determination of Optimum Arrays of Wind Energy Conversion Devices,** G.Bragg, W. Schmidt, *J. Energy*, May/June 1978.

432-11379-210-90

FLOW IN A RECTANGULAR DUCT BEND

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor J. G. H. Howard.
(*d*) Experimental.
(*e*) The development of three-dimensional turbulent boundary layers and the generation of a secondary flow field are measured in duct bends up to 180 with air or water flow. In some cases, a laser-Doppler anemometer is employed. Duct geometries are chosen to include combinations of flow fields commonly occurring in turbomachinery passages.
(*h*) **Measurements of Skewed Boundary Layers in a Curved Duct with Variation in Streamwise Pressure Gradient,** J. Young, J. Howard, *J. Fluids Engrg.* **100,** 1978.

432-11380-630-90

FLOW IN CENTRIFUGAL IMPELLER PASSAGES

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor J. H. G. Howard.
(*d*) Experimental, analytical and design methods.
(*e*) Velocity measurements, recently using a laser-Doppler anemometer, are made in the passage of a water-flow radial impeller. Analysis procedures are under development based on a three-dimensional finite difference approach, employing a two equation turbulence model with Coriolis and curvature effects included. Design procedures are being examined, based on a model with jet and wake regions in the passage and distributed accelerations normal to the relative streamlines.
(*h*) **Measured Passage Velocities in a Radial Impeller with Shrouded and Unshrouded Configurations,** J. Howard, C. Kittmer, *J. Engrg. for Power* **97,** 1975.

A Centrifugal Compressor Flow Analysis Employing a Jet-Wake Passage Flow Model, J. Howard, C. Osborne, *J. Fluids Engrg.* **99,** 1977.

A Laser-Doppler System for Velocity Measurement in a Radial Impeller, J. Howard, T. Naeem, S. Watson, *Proc. Intl. Conf. Centrifugal Compressor Technology,* I.I.T., Madras, 1978.

The Use of Parameters Based on Accelerations Normal to a Relative Streamline in Centrifugal Impeller Design, J. Howard, *Proc. Intl. Conf. Centrifugal Compressor Technology,* I.I.T., Madras, 1978.

WESTERN CANADA HYDRAULIC LABORATORIES LTD., 1186 Pipeline Road, Port Coquitlam, B. C., Canada V3B 4S1. Mr. Duncan Hay, Managing Director.

433-10553-350-73

HYDRAULIC MODEL STUDIES OF SPILLWAY DIVERSION STRUCTURE, LIMESTONE GENERATING STATION

(*b*) Manitoba Hydro.
(*d*) Experimental for design and operation.
(*e*) Evaluate the performance of the spillway, potential erosion, diversion ports and the hydraulic forces on the diversion gates.

433-10557-350-73

HYDRAULIC MODEL STUDIES OF REVELSTOKE PROJECT, COLUMBIA RIVER, B.C.

(*b*) B. C. Hydro and Power Authority.
(*d*) Experimental for design and operation.
(*e*) Evaluate on two separate models the diversion tunnel with appertenant structures with respect to approach conditions, structure performance, hydraulic loadings, tailwater levels, scour potential and operating procedures over a range of discharges.

433-11381-360-75

SETIF HOWELL-BUNGER VALVE OUTLET WORKS

(*b*) Bechtel Corporation, U.S.A.
(*d*) Experimental for design and operation.
(*e*) Using physical models, compare the stilling section of two different dispersion structure designs, modify the most suitable to minimize erosive action and determine the extent of downstream erosion protection. Design for rip-rap protection on the discharge canal invert and banks was also developed.
(*f*) Completed.

433-11382-350-75

HYDRAULIC MODEL STUDIES, AIN ZADA SPILLWAY

(*b*) Bechtel Corporation, U.S.A.
(*d*) Experimental for design and operation.
(*e*) The studies were to rate the spillway crest, refine flip bucket design to prevent erosion from undermining the structure and to optimize the layout of the sidewalls in the chute and transition areas with respect to hydraulic performance and economy of construction.
(*f*) Completed.

433-11383-220-90

A PILOT SAND TRACING STUDY ON THE FRASER FORESHORE

(*b*) Geologic Survey of Canada.
(*d*) Applied research.
(*e*) The study was undertaken to investigate the feasibility of a low cost sand tracing method using dyed tracer sand and to study the migration direction and general rate of sand movement on the foreshore on the Fraser River delta. Fluorescent-dyed sand was placed on the Fraser delta. At regular intervals, the tracer sites were revisited and samples taken and analyzed. Periodic sampling identified the centre of mass of the tracer sand from which the direction and rate of sand movement could be determined.
(*f*) First phase completed.

433-11384-440-90

OKANAGAN LAKE DYE AND DROGUE TRACING

(*b*) Water Investigations Branch, Ministry of the Environment, Victoria, B.C.
(*d*) Field investigation.
(*e*) The study was undertaken to determine water movements over an area 2 miles long by 1 mile out from shore along the east side of Okanagan Lake and to select the most suitable locations for daily water samples to be taken to assess the spread of a seeded herbicide. A preliminary survey was carried out using drogues and fluorometric observation of the travel of a dye slug to determine the rates of ambient water currents and wind induced nearshore transport. A second study was carried out using continuously sampling Turner field fluorometer to trace the spread of Rhodamine WT dye from two constant rate dye injectors located in the herbicide seeding area.
(*f*) Completed.

433-11385-870-90

EVALUATION AND TESTING, PUMPS AND OIL SEPARATORS. ARCTIC MARINE OIL SPILL PROGRAM

(*b*) Environmental Emergency Branch, Environment Canada, Ottawa.
(*d*) Experimental for operations.
(*e*) The study was undertaken to assess commercially available positive displacement pumps and oil spill cleanup operations in remote ice covered waters.

433-11386-340-75

HYDRAULIC MODEL STUDIES OF THE EMERGENCY COOLING SYSTEM INTAKES, SAN ONOFRE NUCLEAR GENERATING STATION

(*b*) Bechtel Corporation, U.S.A.
(*d*) Experimental for design and operation.
(*e*) The purpose was to investigate whether flow-reducing and air entraining vortices would develop in the intakes and to develop modifications for the elimination of vortices.
(*f*) Completed.

433–11387–300–96

AN ASSESSMENT OF THE FLUVIAL GEOMORPHOLOGY OF THE VEDDER RIVER

(*b*) Water Investigations Branch, Victoria, B.C.
(*d*) Field investigation.
(*e*) The history of the Vedder River valley was documented in terms of geomorphology, hydrology, and sediment transport. Insight obtained from these studies was used to analyze proposed flood control schemes which included various combinations of setback dykes, bankline levees, and in-channel gravel removal.
(*f*) Completed.

433-11388-220-90

NORTH ARM BORROW STUDY

(*b*) Public Works Canada, Ottawa.
(*d*) Field investigation.
(*e*) The study was undertaken to determine the rate of infill and downstream migration of large dredged borrow pits in the North Arm of the Fraser River. Bedload and suspended load transport rates were estimated for an average freshet using field data and empirical methods. A numerical model was developed to predict the infill and downstream bedload only and laboratory flume tests were conducted to investigate rates of infill from suspended load.
(*f*) Completed.

433-11389-430-70

PILGRIM WAVE MODEL

(*b*) Axel Johnson Corporation, Engineering Division.
(*d*) Experimental for design and operation.
(*e*) Forces developed on the walls, roof and pump columns at Pilgrim Generating Station intake structure were investigated for 25 feet high incident waves. Special instrumentation was developed to measure the high frequency, high intensity shock loads due to wave impact.
(*f*) Completed.

433-11390-390-75

HYDRAULIC MODEL STUDIES OF SEAWATER INTAKE FACILITIES, QURAYYAH, SAUDI ARABIA

(*b*) Bechtel Corporation, U.S.A.
(*d*) Experimental for design and operation.
(*e*) The study was undertaken to assess flow conditions in the intake structures for a range of pump operating conditions, return flows and water levels and to improve operation, if necessary, through modifications.
(*f*) Completed.

THE UNIVERSITY OF WESTERN ONTARIO, Department of Applied Mathematics, Faculty of Science, Engineering and Mathematical Sciences Building, London, Ontario, Canada N6A 5B9. Professor S. C. R. Dennis, Department Chairman.

434-07995-030-90

TIME DEPENDENT AND STEADY VISCOUS FLUID FLOW

(*b*) Natural Sciences and Engineering Research Council of Canada.
(*c*) Professor S. C. R. Dennis.
(*d*) Theoretical.
(*e*) A number of studies of various flow configurations involving viscous fluids are under way. The objects of the project are to understand the physical nature of the flows concerned, and also to develop numerical techniques of solving the Navier-Stokes equations. Recent work has been concerned with flow in curved tubes and in channels with constrictions, and also with flow near rotating and translating spheres. A project on the numerical simulation of the Taylor column is being carried out jointly with Dr. D. B. Ingham of the University of Leeds, England and Dr. S. N. Singh of the University of Kentucky, Lexington, Kentucky, U.S.A.
(*h*) **Flow in a Curved Tube at Moderate Dean Number,** S. C. R. Dennis, M. Ng, *Proc. 6th Canadian Congress of Applied Mechanics* **2,** pp. 555-556, 1977.
Problems Relating to the Flow in the Neighbourhood of Rotating Spheres, S. C. R. Dennis, S. N. Singh, *Proc. 6th Canadian Congress of Applied Mechanics* **2,** pp. 557-558, 1977.
The Computation of Two-Dimensional Asymmetrical Flow Past Cylinders, S. C. R. Dennis, *Computational Fluid Dynamics* **XI,** *SIAM-AMS Proceedings*, pp. 156-177, 1978.
A Difference Method for Solving the Navier-Stokes Equations, S. C. R. Dennis, J. D. Hudson, *Proc. 1st Intl. Conf. Numerical Methods in Laminar and Turbulent Flow*, Univ. College, Swansea, United Kingdom (Pentech Press, London, England), pp. 69-80, 1978.
Calculation of the Flow Between Two Rotating Spheres by the Method of Series Truncation, S. C. R. Dennis, S. N. Singh, *J. Computational Physics* **28,** pp. 297-314, 1978.
Laminar Boundary Layer on an Impulsively Started Rotating Sphere, S. C. R. Dennis, D. B. Ingham, *Phys. Fluids* **22,** pp. 1-9, 1979.

434-07996-020-90

DIFFUSION IN FLUID FLOWS

(*b*) National Research Council of Canada.
(*c*) Dr. P. J. Sullivan.
(*d*) Theoretical and experimental.
(*e*) A study of both mean and fluctuating concentration values of contaminant in incompressible flow fields is being undertaken. The concept of a local value of longitudinal diffusivity was explored both theoretically and experimentally for a uniformly bound turbulent shear flow and this is currently being extended to the situation in which the flow is inhomogeneous in the streamwise direction. In a simultaneous study of both the dispersion and diffusion problem in a general incompressible flow from an instantaneous source of contaminant, some significant progress is being made.
(*h*) **How Some New Fundamental Results on Relative Turbulent Diffusion can be Relevant in Estuaries and Other Natural Flows,** P. C. Chatwin, P. J. Sullivan, pp. 233-242 in *Hydrodynamics of Estuaries and Fjords*, edited by J. Nihoul, Elsevier Publishing Co., 1978.
The Relative Diffusion of a Cloud of Passive Contaminant in Incompressible Turbulent Flow, P. C. Chatwin, P. J. Sullivan, *J. Fluid Mech.* **91,** pp. 337-356, 1979.

434-09634-400-00

THEORETICAL STUDY OF THE SALINITY AND FLOW PATTERN IN ESTUARIES

(*c*) Dr. H. Rasmussen.
(*d*) Theoretical.
(*e*) A theoretical study of the salinity distribution and the general flow pattern in estuaries is in progress. An approximate steady two-dimensional model has been derived for slightly stratified estuaries and is now being analysed using Galerkin's method.
(*h*) **An Approximate Solution for Two-Dimensional Estuaries,** H. Rasmussen, *Letters in Applied and Engineering Sciences* **16,** pp. 415-421, 1978.

434-10558-820-90

NUMERICAL STUDY OF FREE-SURFACE GROUNDWATER FLOW

(*b*) National Research Council of Canada.
(*c*) Dr. H. Rasmussen.
(*d*) Theoretical.
(*e*) Free-surface flow is modeled by Laplace equation for the velocity potential and nonlinear first-order partial differential equation for the free surface. The potential problem is reformulated as a variational problem and then solved approximately by a Rayleigh-Ritz expansion. The free-surface equation is solved using finite differences.
(*h*) **Solution for Free-Surface Flow in Porous Media Using Rayleigh-Ritz Expansions,** H. Rasmussen, *Trans. CSME-5*, pp. 52-54, 1978/79.

434-11391-270-90

BLOOD FLOW AND ARTERIAL BRANCHING

(*b*) National Research Council of Canada and Ontario Heart Foundation.
(*c*) Dr. M. Zamir.
(*d*) Theoretical.
(*e*) The general aim of this work is to provide an understanding of the fluid dynamic basis of the cardiovascular system. A particular question which has been studied is that of arterial branching and the structure of arterial junctions. Work is in progress on the problem of flow in a bifurcation.
(*h*) **The Role of Shear Forces in Arterial Branching,** M. Zamir, *J. General Physiology* **67,** 213-222, 1976.
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SUBJECT INDEX

NBS-114A (REV. 9-78)

U.S. DEPT. OF COMM.
BIBLIOGRAPHIC DATA SHEET

1. PUBLICATION OR REPORT NO.
NBS SP 583

[redacted]

3. Recipient's Accession No.

4. TITLE AND SUBTITLE

HYDRAULIC RESEARCH IN THE UNITED STATES AND CANADA, 1978

5. Publication Date
October 1980

6. Performing Organization Code

7. ~~AUTHOR(S)~~ Editor
Pauline H. Gurewitz

8. Performing Organ. Report No.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, DC 20234

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS *(Street, City, State, ZIP)*

Same as item 9.

13. Type of Report & Period Covered
Final

14. Sponsoring Agency Code

15. SUPPLEMENTARY NOTES

Library of Congress Catalog Card Number: 80-600124

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

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17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Fluid mechanics; hydraulic engineering; hydraulic research; hydraulics; hydrodynamics; model studies; research summaries.

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19. SECURITY CLASS (THIS REPORT)
UNCLASSIFIED

20. SECURITY CLASS (THIS PAGE)
UNCLASSIFIED

21. NO. OF PRINTED PAGES
397

22. Price
$8.50

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